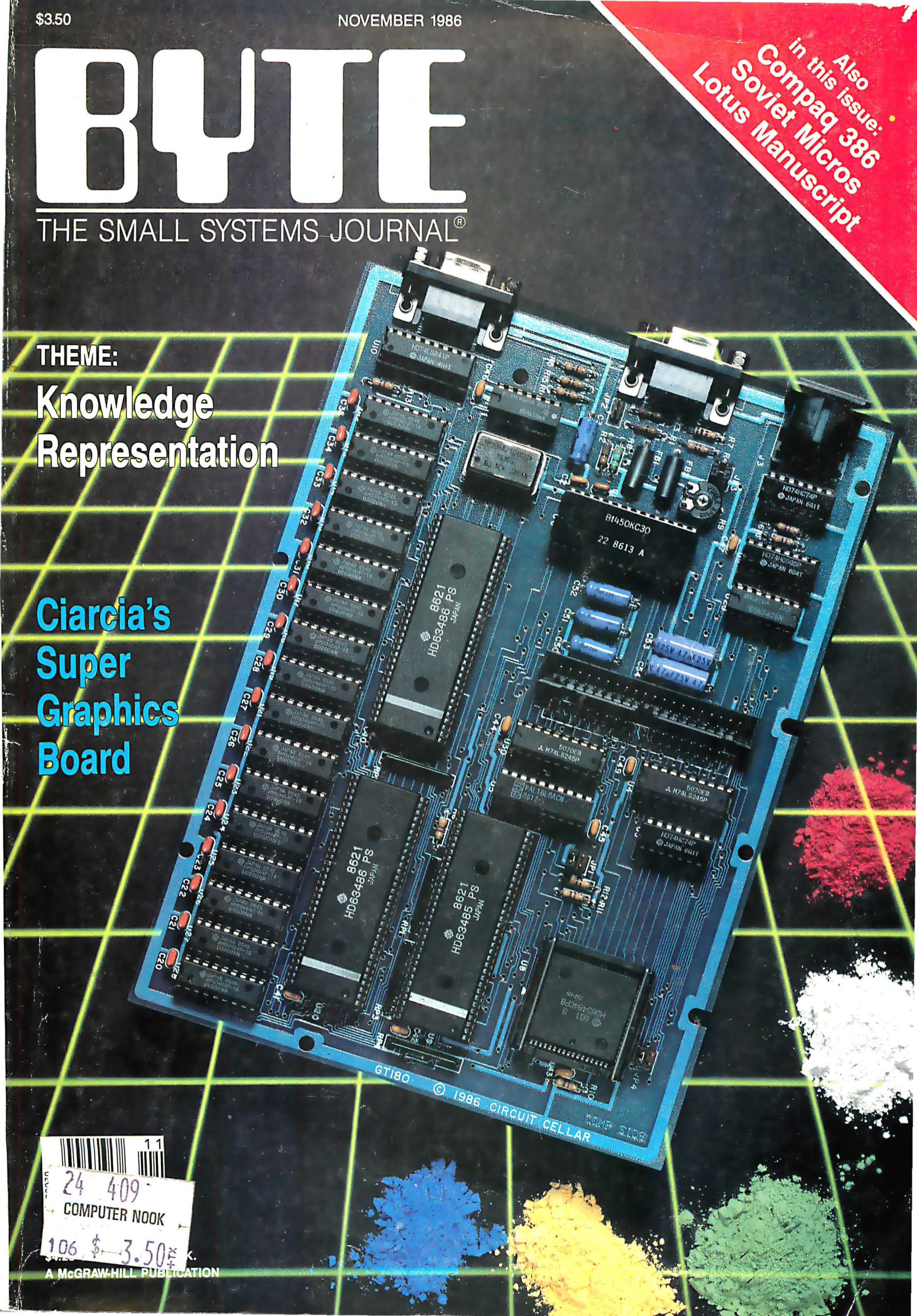


$3.50
NOVEMBER 1986
BYTE
THE SMALL SYSTEMS JOURNAL®
Also in this issue:
Compaq 386
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THEME:
Knowledge Representation
Ciarcia's Super Graphics Board
GT180 © 1986 CIRCUIT CELLAR
A McGRAW-HILL PUBLICATION

Turbo Pascal Programming

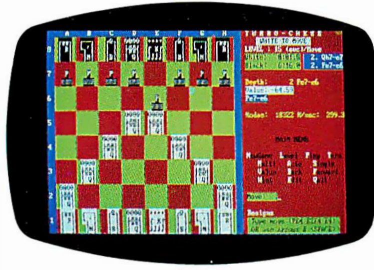
Learn Secrets, Strategies, Game Theory!

INCLUDES SOURCE CODE!

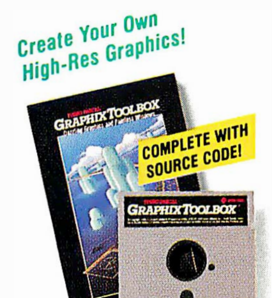
$10.00 Scratch 'n Win Rebate!

Turbo GameWorks®

Also recently released, Turbo GameWorks is what you think it is: "Games" and "Works." Games you can play right away (like Chess, Bridge and Go-Moku), plus the Works—which is how computer games work. All the secrets and strategies of game theory are there for you to learn. You can play the games "as is" or modify them any which way you want. Source code is included to let you do that, and whether you want to write your own games or simply play the off-the-shelf games, Turbo GameWorks will give hours of diversion, education, and intrigue. George Koltanowski, Dean of American Chess, and former President, United States Chess Federation, reacted to Turbo GameWorks like this: "*With Turbo GameWorks, you're on your way to becoming a master chess player.*" And Kit Woolsey, writer, author, and twice Champion of the Blue Ribbon Pairs, wrote, "*Now play the world's most popular card game—Bridge . . . even program your own bidding and scoring conventions.*" Suggested retail: $69.95. Use a $10.00 Scratch 'n Win Rebate and you're talking an *incredible $59.95!* Minimum memory: 192K.



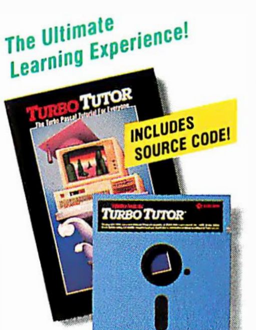
Turbo GameWorks' Chessboard



$10.00 Scratch 'n Win Rebate!

Turbo Graphix Toolbox®

It includes a library of graphics routines for Turbo Pascal programs. Lets even beginning programmers create high-resolution graphics with an IBM, Hercules,™ or compatible graphics adapter. Our Turbo Graphix Toolbox includes all the tools you'll ever need for complex business graphics, easy windowing, and storing screen images to memory. It comes complete with source code, ready to compile. Suggested retail: $69.95, but with a $10.00 Scratch 'n Win Rebate, *only $59.95!* Minimum memory: 192K.



$10.00 Scratch 'n Win Rebate!

COMPLETELY NEW VERSION!

Turbo Tutor® 2.0

The new Turbo Tutor can take you from "What's a computer?" through complex data structures, assembly languages, trees, tips on writing long programs in Turbo Pascal, and a high level of expertise. Source code for everything is included. New split screens allow you to put source text in the bottom half of the screen and run the examples in the top half. There are quizzes that ask you, show you, tell you, teach you. You get a 400-page manual—which is not as daunting as it sounds, because unlike many software manuals, it was not written by orangutans. Suggested retail: $39.95. Use a $10.00 Scratch 'n Win Rebate and you're down to an *unheard of $29.95!* Minimum memory: 192K.



Recognition for Borland International has come from business, trade, and media, and includes both product awards and awards for technical excellence and marketing.

America's Cup. Coming Soon!

How to use Scratch 'n Win Rebates

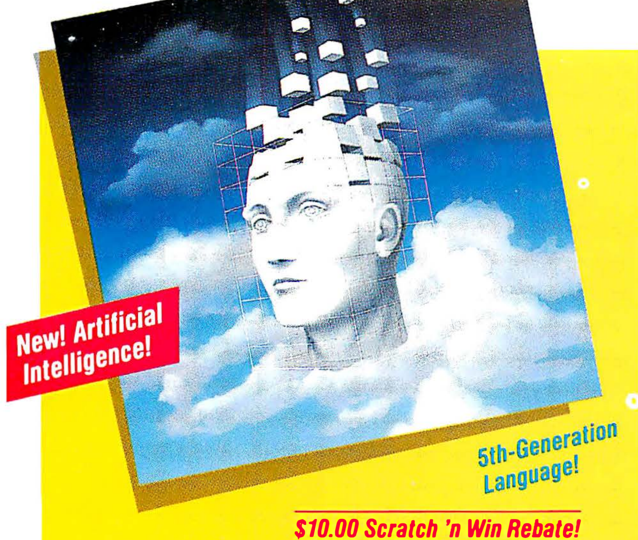
It's really simple. You purchase the product between 9/5/86 and 3/31/87, and return the license agreement along with dated proof of purchase and your rebate card. We'll mail you a check for $10.00 on single product purchases or a check for $15.00 when you buy an advertised "bundle"—which means our Turbo Pascal Jumbo Pack, or Turbo Lightning and Lightning Word Wizard, or Reflex: The Analyst and Reflex Workshop, or SideKick and Traveling SideKick. (Restrictions do apply. See Official Rules on back of Instant Winner card).

Send a buck to the boat!

If you'd like to help America's effort to recapture the America's Cup from Australia, you can make a tax-deductible donation to "Heart of America" Challenge, 11 South LaSalle St., Suite 1670, Chicago, Illinois 60603



Sail designs generated from Shore Sails' Turbo Pascal programs.



Turbo Pascal Programming

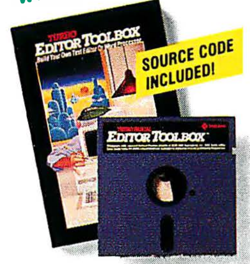
$10.00 Scratch 'n Win Rebate!

Turbo Prolog™

> "If you're at all interested in artificial intelligence, databases, expert systems, or new ways of thinking about programming, by all means plunk down your $100 and buy a copy of Turbo Prolog."
> Bruce Webster, BYTE

"Borland International, Inc. is gunning onto the fast track in the artificial intelligence and engineering-language-software race, riding aboard a new $99 Turbo Prolog," says Tom Schwartz in *Electronic Engineering Times.* And so we are. Our new Turbo Prolog has drawn rave reviews—which we think are well deserved—because Turbo Prolog brings 5th-generation language and supercomputer power to your IBM PC and compatibles. Turbo Prolog is a high-speed compiler for the artificial intelligence language, Prolog, which is probably one of the most powerful programming languages ever conceived. We made a worldwide impact with Turbo Pascal and you can expect the same results and revolution from Turbo Prolog, the natural language of artificial intelligence. Darryl Rubin, writing in *AI Expert* said, *"Turbo Prolog offers generally the fastest and most approachable implementation of Prolog."* Suggested retail, $99.95. Use a $10.00 Scratch 'n Win Rebate and that goes down to only *$89.95!* Minimum memory: 384K.

Build Your Own Word Processor!



$10.00 Scratch 'n Win Rebate!

Turbo Editor Toolbox™

Recently released, we called our new Turbo Editor Toolbox a "construction set to write your own word processor." Peter Feldmann of *PC Magazine* covered it pretty well with, *"A 'write your own word processor' program for intermediate level programmers, with lots of help in the form of prewritten procedures covering everything from word wrap to pull-down windows."* Source code is included, and we also include MicroStar, a full-blown text editor with pull-down menus and windowing. It interfaces directly with Turbo Lightning to let you spell-check your MicroStar files. Jerry Pournelle of *BYTE* magazine said, *"The new Turbo Editor Toolbox is the Turbo Pascal source code to just about anything you ever wanted a PC-compatible text editor to do."* Suggested retail: $69.95. Use a $10.00 Scratch 'n Win Rebate and you'll get all this for *only $59.95!* Minimum memory: 192K.



MicroStar file directory accessed by pull-down menu

Technical Specifications:

TURBO PASCAL 3.0 Minimum memory: 128K; includes 8087 and BCD features for 16-bit MS-DOS and CP/M-86 systems. CP/M-80 version minimum memory: 48K; 8087 and BCD features not available. ***TURBO DATABASE TOOLBOX*** Minimum memory: 128K. CP/M-80 minimum memory: 48K. Requires Turbo Pascal 2.0 or later. ***TURBO GRAPHIX TOOLBOX**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later, Turbo Pascal 3.0, and IBM CGA, Hercules Monochrome Card or equivalent. ***TURBO TUTOR 2.0*** Minimum memory: 192K. CP/M-80 version minimum memory 48K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO EDITOR TOOLBOX**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO GAMEWORKS**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO PROLOG**** Minimum memory: 384K. ***REFLEX: THE ANALYST**** Minimum memory: 384K. Requires IBM CGA, Hercules Monochrome Card or equivalent. Works with Intel's AboveBoard-PC and -AT; AST's RAMpage! and RAMpage! AT; Quadram's Liberty-PC and -AT; Tecmar's 640 Plus; IBM's EGA and 3270/PC; AT&T's 6300 and many others. ***REFLEX WORKSHOP**** Minimum memory: 384K. Requires Reflex: The Analyst. ***TURBO LIGHTNING**** Minimum memory: 256K. Two disk drives required. Hard disk recommended. ***LIGHTNING WORD WIZARD**** Minimum memory: 256K. Requires Turbo Lightning. Turbo Pascal 3.0 required to edit source code. ***SIDEKICK**** Minimum memory: 128K. ***TRAVELING SIDEKICK**** Minimum memory: 256K. ***SUPERKEY**** Minimum memory: 128K. *For IBM PC, AT, XT, PCjr and true compatibles only, running PC/MS-DOS 2.0 or later.

Borland's Business Productivity Programs:

Reflex: The Analyst® Analytical database manager. Provides complete, new look at data normally hidden by programs like 1-2-3® and dBASE.® Best report generator for, and complement to, 1-2-3.

Reflex Workshop™ Important new addition to Reflex: The Analyst. Gives you 22 different templates to run your business right.

SideKick® Complete RAM-resident desktop management includes notepad, dialer, calculator and more.

Traveling SideKick® Electronic version of business/personal diaries, daytime organizers; works with your SideKick files; important professional tool.

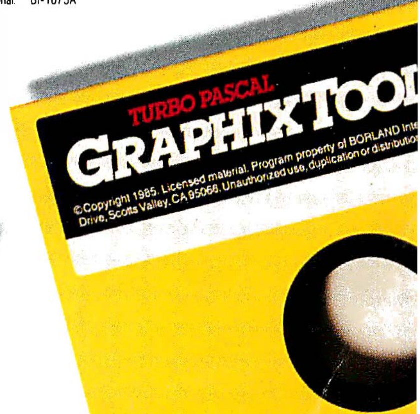
SuperKey® Keyboard enhancer. Simple macros turn 1000 keystrokes into 1. Also encrypts your files to keep confidential files confidential.

Borland's Electronic Reference Programs:

Turbo Lightning® Works with all your programs and checks your spelling *while you type*! Includes 80,000-word Random House® Concise Word List and 50,000-word Random House Thesaurus. Forerunner of Turbo Lightning Library.™

Lightning Word Wizard™ Includes ingenious crossword solver and six other word challenges. If you're into programming, Lightning Word Wizard is also a development toolbox and the technical reference manual for Turbo Lightning.





How Borland is helping bring the America's Cup back to America!

"I think those who grasp the technology will prevail"

Bill Shore, Presid nt, Shore Sails Co., N wport, RI

HEART OF AMERICA

Borland's Philippe Kahn at the helm of America's Cup challenger "Heart of America," with Shore Sails' President Bill Shore

"Sail-making is traditional—a craft—but I think we're huge steps ahead of the competition when we get involved with higher technology," says Shore.

He and Shore Sails' 17 different franchised sail lofts in the U.S. are in what Shore describes as a "highly competitive business, whether it's America's Cup racing or any race." And he adds, "You guys (Borland) do good stuff that's affordable, which is one of the reasons why we wrote all our sail design programs in Turbo Pascal.®"

"These days," he says, "there are many parts to a sail, and Turbo Pascal lets us arrange all the parts properly. We design what the garment industry calls a 'marker'—and rely on Turbo Pascal to do critical things like getting thread lines in the same direction as load lines.

We take the diskette to our new $250,000 laser cutter, which follows the Pascal program precisely, draws out the sail and cuts out the sail. We glue and sew and you've got the best there is."

"The wrong sails will sink your chances—if not your boat—so we wrote Turbo Pascal programs"

Win Fowler, Shore Sails Co., Portland, Maine.

The right sail design, at the right price, right now, has to happen in 17 different Shore Sails Lofts across America.

It had to happen with America's Cup challenger *Heart of America* which carries Shore sails—and it has to happen with the (currently) 700 different boats that Shore Sails has in their Turbo Database Toolbox.™

Sail design, sail pricing and "beating the handicapper" are all done at Shore Sails with Turbo Pascal.

In case you don't know the sharp end from the blunt end of a boat, the right sail design for any boat is more than design and price. It's tactical advantage. Designing sails that take the greatest advantage of the boat's basic design and rigging without getting stuck with a heavier-than-desirable Official Handicap. (Handicaps can eat your chances faster than a Great White.)

The "right sail" design bends but doesn't break the racing rules written by, amongst others, MORC (Midget Offshore Racing Club) or IOR (International Offshore Rules). Turbo Pascal spills out "right sail" designs for Shore Sails so their customers tend to "handicap" the Rules Committee instead of the other way around.

Shore Sails' connection with Borland doesn't end with Turbo Pascal and our Database Toolbox.

Shore's Fowler has also written SuperKey® macros for "every file we have" and says, "We'd be lost without them."

He uses SideKick® to dial every phone call and SideKick's Notepad to communicate between all the Lofts, saying, "That way we don't need a word processor." Shore Sails also uses Turbo Lightning® and Reflex: The Analyst.®

So why so many Borland products in one company?

Win Fowler says, "We'd be sunk without them!"



"Heart of America" sporting its new Borland spinnaker, surfing downwind, Santa Cruz, California

Sail designs generated from Shore Sails' Turbo Pascal programs.

Borland's Instant Winner Game

Scratch this card now and you could *instantly win* 2 free round-trip airline tickets to Australia for the America's Cup Race!

$10,000

First Prize ($10,000 value!) includes accommodations for two in Perth, Australia during the final America's Cup races, which start January 31, 1987. See America win it back after our *only* loss in 134 years! There's more than one *instant winner* in Borland's Instant Winner Game, because you could win one of two new $6,895 4-WD Suzuki Samurai convertibles, or a $4,995 AST TurboLaser™ printer, or a $4,499 Toshiba T3100,™ or a $2,399 Toshiba T1100™ Plus, or a $595 AST SixPakPremium™, or a $69.95 Traveling SideKick,® or any one of hundreds of other Borland products—and at the very least a Borland Rebate Coupon, good for $10 off any single product or $15 off any bundled product offer!



$6,895

$4,499

$69.95

See Official Rules on the back of this card for details.

Don't delay! There will be a second-chance drawing for the trip if not claimed by 12/30/86. There's also a second-chance drawing for the two Suzukis if not claimed by 2/28/87. All rebate coupons are good for products purchased 9/5/86-3/31/87. Product prices above are suggested list prices.

Rub the silver box to reveal whether you win a prize or get a rebate coupon. Then fill in the second-chance entry blank to the right.



Second-Chance Sweepstakes Entry!

We're running two Second-Chance Sweepstakes drawings to award the trip and cars. They *will be won* by someone—it *could be you!* Fill in the entry coupon and mail it now. Winners will be notified immediately, because the final America's Cup races start in Australia on January 31, 1987, and you'll have to pack in a hurry.

(You will need a valid passport and the ability to comprehend Australian versions of the English language.)

Name ______________________

Address ______________________

City ______________________

State __________ Zip __________

OFFICIAL RULES - BORLAND INSTANT WINNER GAME

1. NO PURCHASE NECESSARY: To participate, you may obtain a game card inserted into the October, November, December, or January issue of the following magazines: PC World; Byte; PC Tech Journal; PC Magazine. You may also obtain a game card by mailing a self-addressed, stamped envelope to: Borland International Game Card, P.O. Box 870, Wilton, CT 06897. (Washington State residents send self-addressed envelope.) Limit one game card per stamped request. All requests must be received by January 15, 1987.

2. TO PLAY: Remove the rub-off area on the game card to reveal what prize or rebate offer you have obtained.

3. PRIZES/REBATES: Beneath the rub-off area one of the following prizes may be revealed: Trip for Two to America's Cup Races or $10,000; 1986 Suzuki 4W Samurai Convertible or $6,895; AST Turbo Laser; Toshiba 1100 Portable Computer; Toshiba 3100 Portable Computer; AST Sixpakpremium; AST Advantagepremium; AST 3G Pak; AST Rampage; AST Rampage AT; Free Borland Product, or you may obtain the following rebate offer: $10 rebate offer on any individual product or $15 rebate offer on any single advertised Borland bundle (See rule #11 for prize details.).

4. PRIZE CLAIMS: If you obtain one of the prizes stated in Rule #3, sign your full legal signature on the game card and send via certified mail (copy should be made for your records) along with your name and address to: Borland International Prize Claim, 196 Danbury Road, Wilton, CT 06897. All prize claims must be received or postmarked by February 15, 1987. (See Rule #12 for Trip for Two to America's Cup exception.)

5. REBATE CLAIMS: Rebates are good for products purchased from September 5, 1986 through March 31, 1987. The $10 rebate is good for any individual Borland product and the $15 rebate is good for any advertised Borland software bundle. To receive your rebate you must return your completed license agreement from the manual, this game card and dated proof of purchase to: Borland International, Game Card Rebate, 4585 Scotts Valley Drive, Scotts Valley, CA 95066. Upon receipt of the license agreement, game card and proof of purchase, Borland will send your check. Rebate is not valid with any other rebate or promotion offered directly from Borland.

6. VERIFICATION: All game materials are subject to verification. Game materials are void and will be rejected if not obtained through authorized, legitimate channels, and may be rejected if any part is reproduced, counterfeited, torn or altered in any way, or if materials contain printing, typographical, or mechanical errors. Decisions of the Redemption Center are final. Game pieces from any game other than the Borland Instant Winner Game may not be used in this game.

7. CONDITIONS OF PARTICIPATION: Material submitted becomes the property of Borland International. The submission of game pieces is the sole responsibility of the individual seeking verification, who is solely responsible for lost, late, or misdirected mail. All taxes, registration and inspection fees are the sole responsibility of the verified winner. Winners may be required to execute an affidavit of eligibility and name and likeness publicity release. By participating in the game you accept and agree to be bound by these rules and the decision of the Official Redemption Center which will be final.

8. ELIGIBILITY: Participation is open solely to residents of the United States 18 years of age and over, except employees and agents of Borland International, service agencies, and individuals engaged in the development, production, or distribution of game materials, The Merritt Group, Inc. and their immediate family or members of their households. Void in Vermont and where prohibited by law.

9. GAME SCHEDULE AND AWARD OF PRIZES: The Borland Instant Winner Game will commence on or about September 5, 1986 and end on January 30, 1987. It will officially end, however, when all game pieces are distributed. Verified game prizes will be awarded within thirty (30) days from the date of their receipt for verification at the Official Redemption Center. A major prize winners' list can be obtained by sending a stamped, self-addressed envelope to: Borland Instant Winner Game Winners' List, P.O. Box 7089, Wilton, CT 06897.

10. ODDS CHART: The odds of winning prizes are based upon obtaining the one rare game piece among the applicable number of game pieces.

PRIZE	Qty.	Total Value	Odds of Winning
Trip for Two to America's Cup or $10,000	1	$ 10,000.00	1 in 6,458,000
Suzuki 4W Samurai Convertible JA or $6,895	2	$ 13,790.00	1 in 3,229,000
AST Turbo Laser	1	$ 4,995.00	1 in 6,458,000
Toshiba Portable Computer	2	$ 6,898.00	1 in 3,229,000
AST Memory Boards	25	$ 15,025.00	1 in 258,320
Borland Products	1,000	$149,000.00	1 in 6,458
OVERALL TOTAL	**1,031**	**$199,708.00**	**1 in 6,264**

All remaining game cards will contain a $10 rebate good on any individual Borland product or a $15 rebate good toward any advertised Borland software bundle.

11. PRIZE DETAILS: Trip for two to America's Cup Races (or $10,000) will include coach seating round trip airfare on regularly scheduled commercial airline from San Francisco, California to Perth, Australia and up to two weeks hotel accommodations in Perth, Australia plus $4,500 spending cash. Winners will be responsible for obtaining visa, passport, and all other travel documents. Trip does not include meals, taxes, excess baggage charges and other hotel charges. Minor must be accompanied by parent or legal guardian.

Suzuki 4W Samurai Convertible JA Standard Equipment Package (or $6,895), verified winner will be responsible for all registration, insurance, and licensing fees. AST Turbo Laser, Toshiba Portable Computer Model #T1100; Toshiba Portable Computer Model #T3100; AST Memory Boards and Free Borland Products are non-substitutional except by sponsor due to product availability and all warranties and guarantees are subject to manufacturers terms. All prizes are non-transferrable. Winning consumer is responsible for all local, state and federal taxes.

12. SECOND CHANCE SWEEPSTAKES: There are two Second Chance Sweepstakes drawings scheduled to be conducted on December 31, 1986 and February 28, 1987. Random drawing from all entries received by December 30, 1986 will award trip for two to America's Cup Races (or $10,000). Random drawing from all entries received by February 26, 1987 will award two (2) Suzuki 4W Samurai (or $6,895). All remaining prizes that are unclaimed after February 15, 1987 will remain unclaimed. Send entry to: Second Chance Entry P.O. Box 870 Wilton, CT 06897.

If you have any questions concerning the Borland Instant Winner Game, call: 1-800-451-4471.

The Worldwide Programming Standard

Turbo Pascal Programming!

New Mac Version available!

$10.00 Scratch 'n Win Rebate!

Turbo Pascal® 3.0

"For the IBM® PC, the benchmark Pascal compiler is undoubtedly Borland International's Turbo Pascal," says Gary Ray of *PC Week*. We and more than 500,000 other people around the world think Mr. Ray got that right. Since launch, Turbo Pascal has become the *de facto* worldwide standard in high-speed Pascal compilers. Described by Jeff Duntemann of *PC Magazine* as the *"Language deal of the century,"* Turbo Pascal is now an even better deal than that—because we've *included* the most popular options (BCD reals and 8087 support). What used

Turbo Pascal now includes free 8087 support and BCD!

to cost $124.95 is now only $99.95! You now get a lot more for a lot less: the compiler, a completely integrated programming environment, and BCD reals and 8087 support—all for a suggested retail of only $99.95. And with a Scratch 'n Win $10.00 Rebate, you pay *only $89.95*—which really is the "language deal of the century"! Minimum memory: 128K.

$10.00 Scratch 'n Win Rebate!

Turbo Database Toolbox™

A perfect complement to Turbo Pascal, because it contains a complete library of Pascal procedures that allows you to search and sort data and build powerful database applications. Having Turbo Database Toolbox means you don't have to re-invent the wheel each time you write a Turbo Pascal program. It comes with source code for a free sample database—right on disk. The database can be searched by key words or numbers. Update, add, or delete records as needed. Just compile it and it's ready to go to work for you. (Shore Sails has

Build Your Own Database Applications!

more than 700 boat designs and rigs in their Database Toolbox. See front page story.) Suggested retail: $69.95. With a $10.00 Scratch 'n Win Rebate check back from us, *only $59.95!* Minimum memory: 128K.

SPECIAL PRICES! AMAZING VALUE! ACT NOW!

It's the Works! Everything! The whole electronic enchilada! It's the **Jumbo Pack . . . Turbo Pascal 3.0, Turbo Tutor 2.0, Turbo Editor, Turbo GameWorks, Turbo Graphix** and **Turbo Database.** All 6 Turbo Pascal programs for only $299.95—or **only $284.95** with a $15.00 Scratch 'n Win Rebate! That's about $47.00 each and that's a deal!



Turbo Lightning and **Lightning Word Wizard** for only $149.95! and an **amazing $134.95** after a $15.00 Scratch 'n Win Rebate!

$15.00 Scratch 'n Win Rebate on all Xmas packs!

Save a bundle on our bundles!

SideKick and **Traveling SideKick** for only $125.00 but **only $110.00** after a $15.00 Scratch 'n Win Rebate!

Reflex: The Analyst and the new **Reflex Workshop** for only $199.95! And a $15.00 Scratch 'n Win Rebate cuts that down to **only $184.95!**

YES! I want the best!

For credit card orders or the dealer nearest you
call (800) 255-8008
in CA call (800) 742-1133

Copies	Product	Price	Totals
__	Turbo Pascal 3.0 w/8087 & BCD	$99.95	$____
__	Reflex: The Analyst	149.95*	$____
__	Reflex Workshop	69.95*	$____
__	Reflex, Reflex Workshop	199.95*	$____
__	Turbo Prolog	99.95	$____
__	Turbo Pascal for CP/M-80	69.95	$____
__	Turbo Database Toolbox	69.95	$____
__	Turbo Graphix Toolbox	69.95	$____
__	Turbo Tutor 2.0	39.95	$____
__	Turbo Editor Toolbox	69.95	$____
__	Turbo GameWorks	69.95	$____
__	Turbo Lightning	99.95	$____
__	Lightning Word Wizard	69.95	$____
__	Turbo Lightning, Lightning Word Wizard	149.95	$____
__	SideKick	84.95	$____
__	Traveling SideKick	69.95*	$____
__	SideKick, Traveling SideKick	125.00*	$____
__	SuperKey	69.95	$____
__	Turbo Jumbo Pack	299.95	$____
	Outside USA add $10 per copy CA and MA res. add sales tax		$____
	Amount enclosed		$____

Prices include shipping to all US cities.

Carefully describe your computer system:
Mine is: __ 8-bit __ 16-bit
I use: __ PC-DOS __ CP/M-80
__ MS-DOS __ CP/M-86
My computer's name and model is: ____________

The disk size I use is: ☐ 3½" ☐ 5¼" ☐ 8"
Payment: VISA MC Money order Check
Credit card expiration date ___/___
Card # ____________

Name: ____________
Shipping Address: ____________
City: ____________
State: ________ Zip: ________
Telephone: ____________

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*Limited Time Offer

GF15

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60-DAY MONEY-BACK GUARANTEE
If within 60 days of purchase you find that this product does not perform in accordance with our claims, call our customer service department and we will gladly arrange a refund.

All prices are suggested list prices and are subject to change without notice.

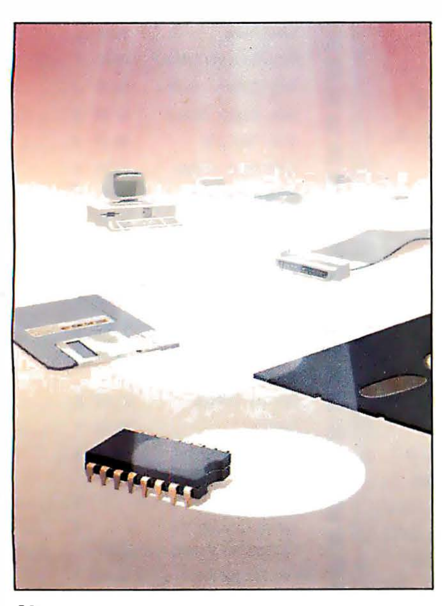


Vive la différence

Inquiry 50 for End-Users.
Inquiry 51 for DEALERS ONLY.

Pictured on the cover is the GT180 color graphics display board from Ciarcia's Circuit Cellar. The printed circuit board was made by drawing a schematic and producing a net list using SCHEMA and then using a Calay auto-routing CAD system at Custom Photo and Design (Wallingford, CT). The finished films were given to Tech Circuits (Wallingford, CT) for production of the PCB. The entire schematic-to-board process took 24 hours. Steve Ciarcia would like to extend special thanks to Greg Peterson, Phil Walton, Ray Long, and Jim McGrath for their fast turnaround on this project.

C·O·N·T·E·N·T·S



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FEATURES

THEME: REPRESENTING KNOWLEDGE

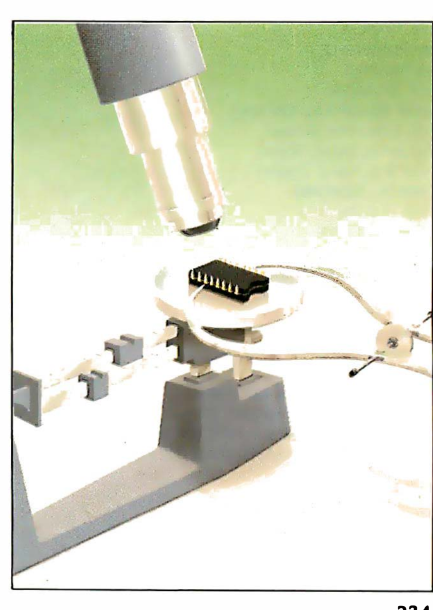
REVIEWS

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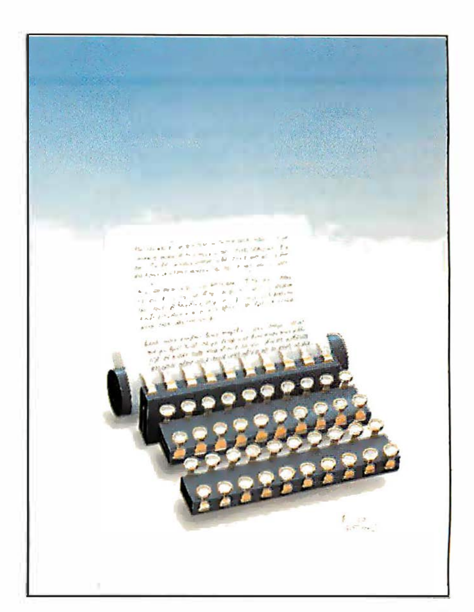


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BYTE AND THE 80386

During the next several months, BYTE will cover Intel's 32-bit microprocessor, the 80386, in unprecedented breadth and depth. We will offer articles in print in BYTE and interactive on-line events on BIX. The combination of in-depth articles with open on-line discussions promises to give BYTE's readers a head start into an exciting new world.

BYTE has already covered the 80386 extensively. In our special issue, *Inside the IBM PCs* (which is still available on newsstands), we provide Paul Wells's introductory article "Intel's 80386 Architecture," Bill Nicholls's lucid sidebar "Systems Implications of the Intel 80386," and Jon Shiell's insightful "Virtual Memory, Virtual Machines."

This issue of BYTE contains a preview of Compaq's impressive Deskpro 386 by Tom Thompson and Dennis Allen on page 84. We posted the same article on BIX on September 9, the date of the Compaq announcement. As is the case with other 80386 systems that have so far appeared, the Deskpro 386 is much more powerful than an 80286-based system despite the lack of systems software to tap the new chip's full power. To the user, the Deskpro 386 seems to be a blazingly fast IBM PC AT, the culmination of the IBM PC-compatible movement rather than the first brave inhabitant of a new world.

Only new systems software can give the Deskpro 386 and other 80386-based systems the full benefit of their magnificent new microprocessor. Two BIX events related to the 80386 are now under way. One of these concerns 80386 systems software; the other event provides a forum for users of the early 80386-based machines.

The systems software picture on the 80386 is fascinating and complex. Users have a choice of DOS under UNIX, from either Phoenix Software or Interactive Systems; DOS merged with UNIX, from either Locus or Microport; Softguard's VM-like VM/386, which also has a DOS emulator; XENIX from Microsoft; or the forthcoming and as yet unnamed Microsoft operating system that succeeds MS-DOS. In order to choose among these, computer users need to ask themselves what, if anything, VM, the mainframe operating system, and UNIX, the popular minicomputer and supermicrocomputer operating system, can provide users of small computers who have done nicely with operating systems like MS-DOS and CP/M.

Clearly, access to large memory is a must—but what else? Operating systems designed to divide the resources of one big machine among several users may or may not have special advantages for the user with an individual dedicated machine—in short, a personal computer. Peter Calingaert's *Operating System Elements: A User Perspective* (Prentice-Hall, 1982) points out that the provision of a virtual machine "costs both storage and speed of execution." In a personal computer, is the virtual machine worth the price? The BIX conference on 80386 systems software is an ideal place to seek the answer. You can take part in this conference by logging on to BIX and typing "join OS386."

The BIX conference on early user experience with 80386 machines will let us all explore these new machines even if we don't yet have access to one. We are offering free BIX connect time for the first 10 users who will share their experiences with 80386-based machines like Compaq's Deskpro 386. (See the accompanying text box for more details.) Other users are welcome to participate as well. To join this conference, log on to BIX and type "join users386."

Highlights of the 80386 conferences will appear in print in BYTE. We will also offer several more 80386 articles in the next few months. Jon Shiell is preparing three more articles—one on what is involved in a VM operating system on the 80386; a second on VM and what it has to offer; and a third on the Cheetah CPU/386, a kit for upgrading an IBM-compatible 80286-based system to use an 80386. The kit and support from Cheetah will be available to BYTE readers who want to explore the 80386 now but aren't yet ready to take the plunge and buy an 80386-based system. BIX will be the setting for a users group for the Cheetah CPU/386.

We also will offer a multipart introduction to Microsoft's new operating system, which is sure to be an important one for the 80386. In fact, it may prove to be as dominant in the single-user environment as MS-DOS has been on the 8088/86 and 80286. Gordon Letwin, a BYTE author from way back (October 1978, to be exact), heads up the Microsoft project to develop this new operating system. Microsoft has released no information about it yet, but industry sources have provided us with some of the system's important generalities.

First, although this new software borrows some features from UNIX, it is intended as an ideal environment for individual users of personal computers in networks. The original design goals of UNIX were quite different. The new Microsoft operating system is based on algorithms that optimize response time for the user, rather than throughput for the system as a whole. Second, the operating system is not a mere extension of MS-DOS. It is a truly new system that has backward compatibility as one of its features. To appreciate and exploit the new powers of this operating system, users will need to learn its ins and outs. Gordon Letwin's introductory article will give the structure of the new operating system and explain how programmers can use it to their advantage.

We will provide discussions of the new Microsoft operating system on BIX when information becomes available from Microsoft and early users of the new software. See you there.

—*Phil Lemmons*
Editor in Chief

Free BIX Hours to Discuss 80386 Machines

The first 10 owners of 80386-based machines who contact us will receive 10 free connect hours for the subsequent month if they agree to share their experiences with the machines with other BIX users. To pursue this, 80386-system owners should contact BYTE Associate Technical Editor Curt Franklin at (603) 924-9281. All BIX users are welcome to participate in the BIX conference "users386" at regular BIX connect-time charges.

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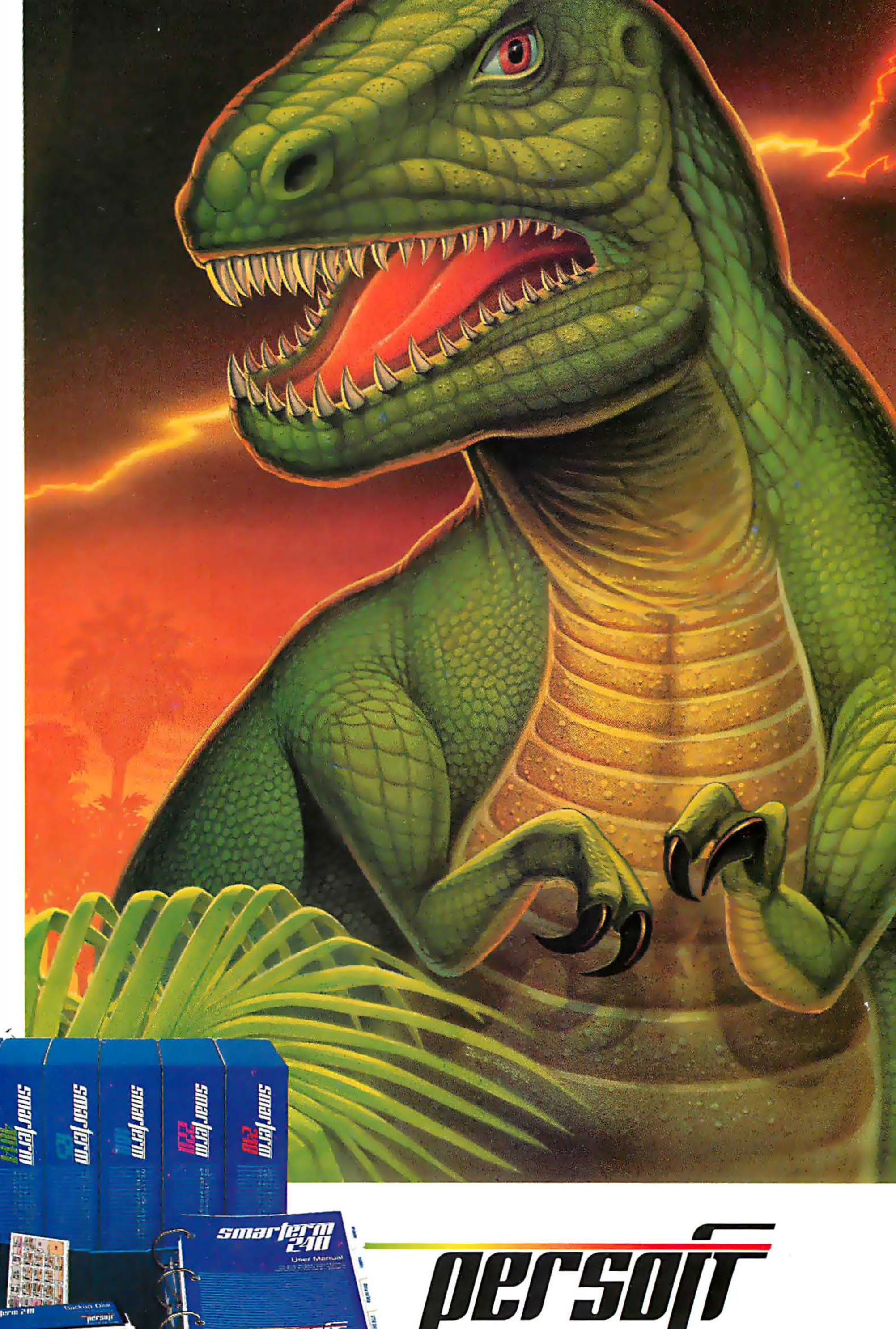
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Staff-written highlights of developments in technology and the microcomputer industry.

"Neuron" Chips Emulate Brain Cells, Hold Promise of Much Faster Processors

Perhaps the most complex data communications system of all is the neural network found in even the simplest of animals. These extremely complex interconnecting structures allow most animals to perform pattern-recognition tasks that even today can be approximated only by the largest supercomputer.

One division of AT&T's Bell Laboratories (Holmdel, NJ) is trying to develop better pattern-recognition capabilities by emulating very simple neural networks on integrated circuit chips. Some of this work has evolved from studies at another division of Bell Labs concentrating on the neural networks of slugs.

So far, the researchers have designed three electronic neural network (ENN) chips. The first, with 22 neurons and 22 input channels, was successfully tested last March. A second chip, with 54 neurons and input channels, was successfully tested in September. This chip contains almost 3000 synapses, connecting each input with each electronic neuron. Each synapse is a programmable resistor, which can be adjusted during the ENN's learning period.

Design work has just been completed on a 256-neuron chip, which will be built using a combination of standard CMOS and electron beam lithography. A fourth chip, with 512 neurons, is in the design stages.

The 54-neuron chip has been tested using simple search tasks. The chip was first "taught" a list of names. It was then shown a new name and asked which name on the list was most like it.

Because of the inherently parallel structure of the network, it can perform such tasks much faster than a conventional processor. According to Larry Jackel, head of Bell Labs' Device Structure Research Department, ENN chips can perform these tasks 100 to 1000 times faster than a conventional computer, and perhaps 10 to 30 times faster than special-purpose hardware. The response time of each electronic neuron is only 400 nanoseconds, much faster than a biological neuron.

The relatively small size of the resistors used on these chips makes possible a very high chip density, higher than that associated with conventional transistor-based circuits. Complexity of future chips may be somewhat limited, however, by the number of input connectors that can be added. Multiplexing the connectors may ease this problem but then might cause its own bottleneck. Jackel says his group is also working on combining the ENNs in hierarchically structured gangs.

IBM to Drop CGA; EGA Next on Chopping Block

IBM has moved to drop the Color Graphics Adapter from its line of available video cards. The company will also drop its CGA monitors, which have been the mainstay of color video for IBM since the introduction of its PC five years ago. According to a highly placed industry marketing executive, IBM's Enhanced Graphics Adapter and monitor are next on the chopping block.

"IBM will move to a system called the EGA Plus," the executive told Microbytes Daily. "Video is the only area where IBM can make big improvements quickly, and this is what you'll see," he said. He added that the EGA Plus will have higher resolution than the current EGA card but will not achieve the sought-after goal of 1024 by 1024 pixels. "That simply requires too much video memory to fit into their cost structure," the executive said.

The source declined to say when Big Blue would make the changes, but he did say it would be "within 12 months." He added, however, that other companies are on the trail of the EGA Plus. "Keep your eye on Paradise [Systems]," he said. "That's the same system that IBM will be using, but Paradise will release it first."

(continued)

Math Model Lets Engineers Simulate Earthquakes

Engineers at EPI-Center (Palo Alto, CA), an environmental engineering firm, and the Stanford University Earthquake Engineering Center have developed an earthquake analysis program. Called the Seismic Survival Indicator (SSI), the program is a mathematical model that's used with Lotus 1-2-3. SSI, which runs on an HP-110 portable computer for on-site analysis, provides structural analysis of a building's resistance to earthquakes.

Once the engineer enters data, including information about horizontal and vertical symmetry of the building, weight of the roof, amount of glass, and type of building material, an earthquake is mathematically simulated; the program returns the amount of structural damage as a percentage between 0 and 100 (0 indicating no potential damage, 100 meaning total collapse). When the data is used in conjunction with a review of building plans and local geography, recommendations regarding building design and insurance requirements can be made.

Beta tests on the program were run in the Coalinga and Morgan Hill districts of California, areas that have received heavy earthquake damage within the last three years. Engineers compared program results with real results and found that virtually all simulated results were within 1 or 2 percentage points of actual damages.

SSI is limited to single-site analysis and structures less than three floors in height.

Macintosh Helps Shape New Techniques in Metalwork

Mark Stanitz, an assistant professor in the School for American Craftsmen at Rochester Institute of Technology (Rochester, NY), is using an Apple Macintosh and Imagewriter for goldsmithing and other metalwork. He does design work on the Macintosh, removes the Imagewriter's ribbon, and then runs pure 24K gold or silver foil 3/1000 inch thick through the printer. The Imagewriter's printhead replaces the hammer and tool traditionally used to shape and decorate metal; it creates a shallow bas-relief of 15/1000 inch, similar to the impression on a quarter.

Stanitz coats the back of the foil with an epoxy resin, which fills the negative areas and hardens. He can then cold-set his creation with prongs or bezels into a superstructure (a piece of jewelry, for example). Other applications include copper wall murals created with MacDraw and hollowware fashioned by molding the foil and electroplating the back of it.

Advantages to Stanitz's method include faster and more exact geometric design and more efficient production work. Also, a goldsmith can incorporate pure materials, such as 24K gold, into jewelry at a small price. And perhaps most important, artists can spend 90 to 95 percent of their time on creative design and only 5 to 10 percent on mechanical processes.

Talking Tablet Speaks in Different Voices

Personal Data Systems (Campbell, CA), an electronics design firm specializing in computer aids for the visually handicapped, is working on an 8086-based briefcase-size computer called the Talking Tablet. The computer, designed and built by Noel Runyon, a blind electronics engineer and computer scientist who is president of the company, consists of a CPU and a detachable IBM-like keyboard. The CPU includes an 80-column by 25-line touch tablet that "displays" data that normally appears on a CRT. As you pass your fingers across the tablet, a built-in speaker "voices" the information that "appears on" the tablet. The speaker also repeats whatever you type in character, word, or line format.

The Talking Tablet is intelligent in the sense that it recognizes emphasis and format. Words that appear on a CRT in boldface or reverse video are spoken in a different voice pitch. Date, time, dollar, address, abbreviations, and other formats also are understood. For example, if you enter "1986," the Tablet returns it as "one-thousand nine-hundred eighty-six"; if you enter the address "St. John St.," it is returned as "Saint John Street." The speech circuitry is proprietary but uses a commercially available speech-synthesis chip.

The Talking Tablet's internal data storage is 756K bytes with a nonvolatile RAM disk; there's battery backup for static RAM. The built-in word processor can read MS-DOS text files as long as special graphics characters aren't present. Delivery dates and prices were unavailable at press time.

Zenith Chief Forecasts Multimegabyte Floppies, 386-based Machine

Multimegabyte floppy disks and a Zenith 80386-based machine will soon be with us, according to Robert Dilworth, president of Zenith Data Systems (Glenview, IL). Speaking at the

(continued)

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Air Force Small Computer Conference. Dilworth also indicated that a read/write optical disk may already be in final development.

Dilworth told Microbytes Daily that he expects big changes in mass storage. His forecast includes 20-megabyte floppy disks, hard disks that are so rugged they can be dropped on the floor without damage, and optical disks with full read/write capability. He said that all these products are under development and should be available soon. He also announced that Zenith would begin designing products that use 1-megabit RAM chips.

Dilworth said ZDS would introduce a computer based on the Intel 80386 "earlier than any other major company." (Compaq Computer Corp. of Houston, certainly a major company, rolled out the Deskpro 386 in early September, less than a month after Dilworth's claim.) Zenith has already introduced a 32-bit bus for its 240 line of IBM PC AT clones. Dilworth said most manufacturers will introduce 80386 machines that are simply faster versions of 80286 machines.

French Firm's System Allows Handwritten Input

Anatex has developed a combination software/hardware package that lets users input handwritten notes into a Macintosh. The system, called Personal Writer, uses special software with a Summagraphics graphics tablet. The software lets the user emulate both the keyboard and the mouse merely by moving the stylus of the graphics tablet in a certain way. Since handwriting varies dramatically from person to person, the user can teach the system to recognize his or her own style. According to Xavier Maury, general manager of the company, the system can be taught to recognize the handwriting of almost every possible user, except those with bizarre penmanship.

Personal Writer will be available initially for the Mac in the first quarter of next year. An IBM PC version will reportedly be available in the second quarter.

Anatex is located at 18 Rue Troyon, F-75017, Paris, France; the telephone number is (1) 47 66 02 60.

NANOBYTES

Xerox Palo Alto Research Center and **Xerox Artificial Intelligence Systems** (Palo Alto, CA) have jointly designed the Xerox VLSI Common LISP Processor. The microprocessor, which has a reduced LISP instruction set hard-coded on the chip (hence its nickname "LISP-on-a-chip"), supports both Common LISP ("CommonLoops") and the Xerox Artificial Intelligence Environment. The 40-bit device is the first object-oriented-program chip of its kind. . . . At the Seybold Desktop Publishing Conference, Microsoft's **Bill Gates** said that at least 10 firms would introduce plug-in full-page displays with graphics coprocessors for IBM PC compatibles at COMDEX this month. . . . **Fairchild Semiconductor** (Cupertino, CA) will begin shipping early in 1987 a 40-MHz version of its CMOS 32-bit Clipper microprocessor. The new chip set will execute as many as 6.5 million instructions per second, Fairchild says. The current Clipper—actually a CPU chip and two cache/memory-management chips mounted on a 3- by 4½-inch printed circuit board—executes 5 MIPS at 33 MHz and supports floating-point arithmetic. . . . **Locus Computing** (Santa Monica, CA) has licensed its PC-Interface software to Motorola Computer Systems. The software will be ported to the UNIX-based System 6300, 6350, 6400, and the 68020, as well as the VME-based 8000, for use as an MS-DOS file server. A Locus spokesperson said this will give users of IBM PCs and compatibles access to Motorola systems running UNIX System V. . . . **Atari Corp. Ltd.** (Berkshire, UK) unwrapped two new models of its ST, as well as a blitter chip that speeds graphics performance, at the Personal Computer World Show in London. The new 2080STF and 4160STF have memory capacities of 2 and 4 megabytes, respectively. The blit chip increases the speed of graphics applications by at least five times, the company claims. . . . Talking about microcomputers, **Richard Carver**, assistant secretary of the Air Force, said, "We can't go to war without these computers." Opening the Air Force Small Computer Conference, Carver said microcomputers "should be viewed as another weapon system."

TECHNOLOGY NEWS WANTED. *The news staff at* BYTE *is always interested in hearing about new technological and scientific developments that might have an impact on microcomputers and the people who use them. We also want to keep track of innovative uses of that technology. If you know of advances or projects that involve research relevant to microcomputing and want to share that information, please contact us. Phone the Microbytes staff at* (603) 924-9281, *send mail on* BIX *to Microbytes, or write to us at* One Phoenix Mill Lane, Peterborough, NH 03458.

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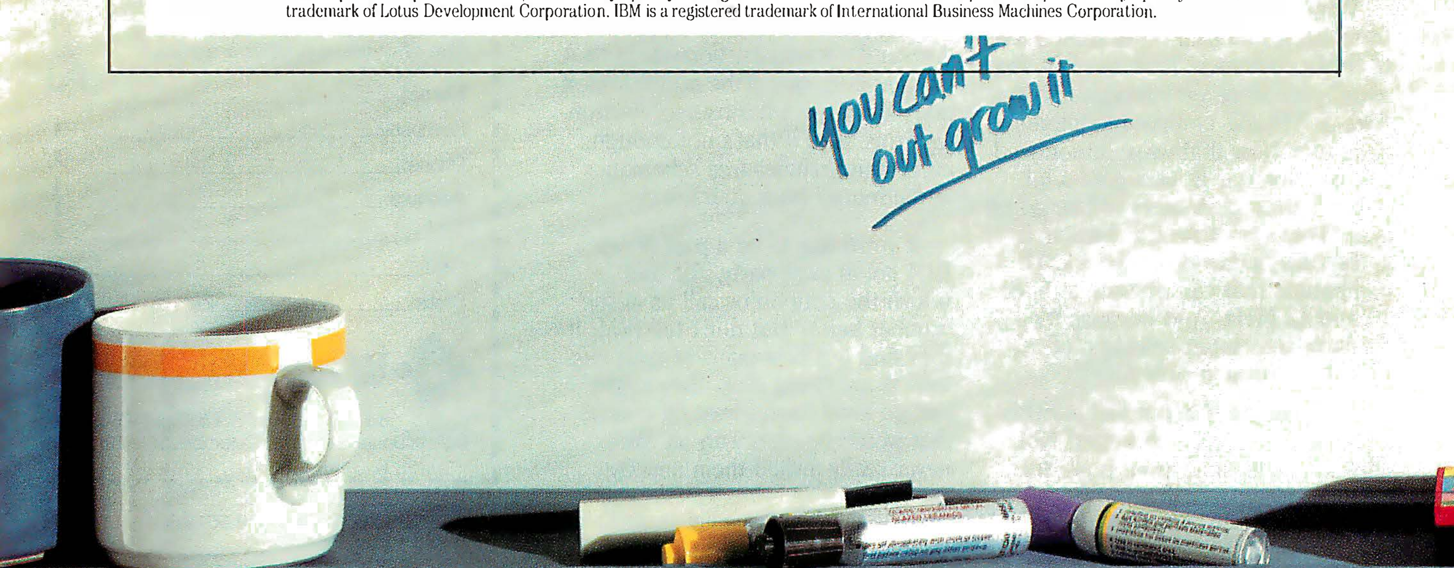
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As the result of a telephone interview by a member of your New York–based editorial staff, BYTE published a small description of the Isocrates project here at Brown University in your July issue (Microbytes). While we appreciate the attention your publication has brought to our work, the description, as published, misstated what we are doing. Isocrates is very much a collaborative project, and much of what your description has attributed to "researchers at Brown University" is in fact the work of others who have been kind enough to share their work with us.

The Greek database itself (i.e., the machine-readable version of Greek authors) is the result of over a decade of data entry, verification, and maintenance by the staff of the Thesaurus Linguae Graecae (TLG) at the University of California, Irvine, and is the property of the TLG. It is used by Brown University under license from the TLG. Any distribution or use of a CD-ROM containing this database is at the discretion of the TLG. The TLG has in fact produced two CD-ROMs, referred to as the A and B disks. The A disk was produced in 1985 and contains the texts of the Greek database as well as Latin, Hebrew, and Coptic texts. The B disk, which was produced this spring, contains the Greek database plus indices. The role of the Institute of Research in Information and Scholarship (IRIS) in the production of the "TLG Pilot CD-ROM #B for Experimental Purposes" (the B disk) was limited to the creation of the index files and the formatting of the data for pressing. The production of the CD-ROM is the work of the TLG under the direction of Theodore Brunner and was supported by a grant from the David and Lucille Packard Foundation.

The ability of "Greek scholars. . .to find. . .every occurrence of a particular word in the work of an ancient author" has existed for some time now and is not the result of work done at Brown University. Our part has been in porting programs that do this to the IBM RT PC and integrating them with one of the TLG's CD-ROMs.

The modification of the Macintosh terminal program you mention that allows the Macintosh to display Greek text is the work of SMK (5760 South Blackstone Ave., Chicago, IL 60637), maker of GreekKeys, classical Greek fonts for the Mac. It is used at Brown and at a number of campuses around the country.

PAUL KAHN
Institute of Research in Information and Scholarship (IRIS)
Brown University
Providence, RI

SKIP THE MENU

Ezra Shapiro's August column provided a brief look at Microsoft Word 3.0, the latest version of that valuable program. Since he seems to be undecided about the overall value of what is one of the best word processors for MS-DOS machines, I thought I'd clear up one point.

Shapiro says, "I loathe the Microsoft interface (. . .with the useless box around the screen and the menu along the bottom)." Well, nothing can be done about the box, but the menu is easily eliminated. If he will select "Options" from the first menu, he can eliminate the menu display by selecting the "Menu: no" option. Word then drops the menu, adding room for three extra lines of text to the screen. When Escape is pressed, the menu pops back into view, disappearing again after a command is chosen.

Given Word's outstanding printer support and other powerful features, it seems a shame to judge it on an easily correctable interface.

GEORGE CAMPBELL
Los Osos, CA

COMPARING CLOCK RATES

When I upgraded myself from my 1977 Apple to a new Leading Edge, one of the reasons for the change was the attractive clock rate of the 8088 processor, which is 4.66 times faster than the old 6502. Thus, my programs should run faster, which is nice.

Indeed, modest research into the execution times of various 8088 commands indicated that increased speed could be expected. Using the timing technique I've outlined elsewhere (*Computing with the Apple*, Reston, 1984), I obtained the following figures for some 8088 operations, expressed in terms of number of executions per second:

NOP	1,300,000
MOV BX,CD	350,000
MOV BX, AX	990,100
INC BX	1,080,000
ADD BX,CD	350,000
ADD BX,[1001]	165,000
MOV BX, [1001]	235,000

Corresponding times for the 6502 are simpler: Except for NOP and BRK, every instruction executes at the rate of 262,000 per second.

But such comparisons don't show what one really wants to know, namely, what can one expect in the way of speedup for ordinary, run-of-the-mill programs? After all, it is difficult to imagine a meaningful program made up of NOPs and register-to-register operations.

On the other hand, it is an ancient principle in computing that benchmarks can be devised to show that any machine is faster than any other machine. A program that capitalizes on certain characteristics of the 8088 (e.g., the inclusion of multiply and divide commands) should beat any program for the 6502 (or the 8080, or the Z80) that needs multiplication or division. Similarly, it should be possible to find features of the 6502 that would run circles around the 8088.

So, to satisfy my own curiosity, I decided on this program:

1. Generate ten random bytes.
2. Bubble-sort them.
3. Repeat 2000 times.

The ingenious random-number genera-

(continued)

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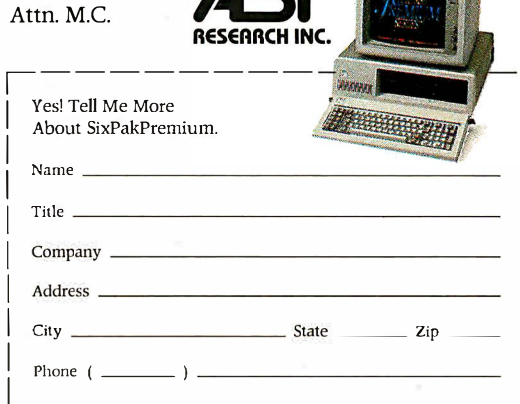


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tor of Art Matheny (*Micro*, August 1982) is short and simple, passes every test except the correlation test, and uses only simple addition. It can be coded identically on the 6502 and the 8088.

After many trials, to cancel out any extremes caused by randomness, the time for the runs of 2000 was 6.38 seconds for the 6502 and 6.90 for the 8088.

This will lead to lots of wailing on the part of 8088 devotees. I would suggest that you take some program that you devise and make your own comparison.

My point is this: The widely acclaimed clock speed of the 8088 is almost meaningless, since the number of bytes per instruction can range from one to six. What counts is the mix of commands that *your* work requires.

I was astonished, however, to discover that, for the first program I could think of for a test, the 6502 turned out to be nearly 8 percent *faster* than the 8088.

FRED GRUENBERGER
Northridge, CA

In Search of Cheaper Transmission

More people are spending a lot of time communicating via modem these days. One major hassle with Buzby (British Telecom) and Ma Bell is uploading and downloading large amounts of text. Even at 1200 baud (not too common in Britain yet), it seems to take several eternities for even a short piece of text to wend its electronic way. Higher baud rates tend to require special (expensive) leased lines and require the user at the other end to have similar (expensive) equipment.

When dealing with text, the same characters often keep appearing in the same order: In this letter, the word "the" appears 24 times; including the terminating space, this requires 32 bits each time you want to send the same word. Given the move to 16-bit machines, perhaps it is time for an extended ASCII set to be introduced for datacomm transmission of text. I envision it as something like this:

The basic ASCII code would be a subset of this new code. With bit 7 = 0, the byte would be treated as a single standard ASCII code. If, however, bit 7 = 1, the lower 7 bits of this byte and the 8 of the following byte would be treated as a single 15-bit entity, giving 32,768 separate meanings.

This could be an index to a standard predisseminated dictionary of common words and regularly occurring letter groups (the latter technical terms). Each language could have its own dictionary; by selecting the same code for the word

(continued)

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with the same meaning in different languages, it would even provide the basis for a crude language translator.

There are other refinements, such as using bits to switch "Trailing space" or "Leading character capitalized" on and off for individual codes, but the fine details would be better left to a standards committee to nail down and enforce. It is worth noting that this will also allow large text databases (such as the text of a megablockbusting novel) to be compressed to perhaps 25 percent of their original storage space. My own personal dream is to have the complete runs of Astounding/Analog, Fantasy and Science Fiction, Galaxy, and all the other SF magazines on one CD-ROM in machine-readable and machine-searchable form; duplication cost: about ten bucks. The transcription and royalty costs are another problem, but we have the technology.

ROBERT SNEDDON
Glasgow, Scotland

Not Your Basic BASIC

ZBasic is fast and is the only interpiler that creates .COM files in CP/M (and so it has no BASIC competitors) but I had hoped for more when I bought it. In fact, I had hoped for what the ZBasic ad promises: "It retains the old commands you already know." Well, some, but not all. Its differences require hours to convert MBASIC-80 programs to ZBasic. For example, SORT works fine in MBASIC-80 but not in ZBasic, because SORT contains OR, a reserved word, within it. (Microsoft solved the embedded-words problem five years ago!) SORT is only one of many examples of translations that ZBasic requires. MBASIC allows periods in variables (SORT.SCORES), but ZBasic allows only underlines (SORT_SCORES).

ZBasic is a hacker's paradise, with data types carried to absurdity, making it totally wrong for education. For example, for PRINT 1/3, ZBasic gives the false answer of zero! To get a correct answer, ZBasic needs one of these: 1./3, or 1!/3, or 1#/3. And as if four compulsory data types were not enough, ZBasic also provides 2 to 54 digits of precision, which programmers may use to produce data files with enough variations in numbers to confound and confuse not only others, but even the unwary programmer himself when he attempts to use such data files later without knowing the exact digits of precision in the data file. Applesoft, North Star BASIC, and Turbo Pascal opted to keep data simple—much to the convenience of the users—and ZBasic could have provided a default of one precision (maybe 11 digits, like Turbo Pascal) and allowed other options for the hackers.

In many ways ZBasic is a modern, powerful, fast, ingenious implementation of BASIC, but in other ways it is five years out of date.

EDWARD L. TOTTLE
Baltimore, MD

Computers in Music

I think BYTE is missing an opportunity. I expect that there is a large portion of your readership that would be interested in a regular column that examines the MIDI interface and MIDI devices.

Computers and music seem to go together, especially in this digital age, and many programmers are also interested in music. After having my interest piqued by your June (Computers and Music) issue, I started to look through music stores and picked up a copy of *Keyboard* magazine. Although I've been a loyal BYTE reader since 1978 and have read several other personal computer magazines as well, I was caught completely by surprise by the capabilities of even inexpensive MIDI synthesizers and the scope and state of the art of MIDI software.

Your June issue presented an excellent overview of the hardware and software that's now literally taking over the music world, but an issue every year or so that deals with music can at best hit only the very high spots. *Keyboard* has a regular column on programming. Perhaps BYTE should have a regular column on music.

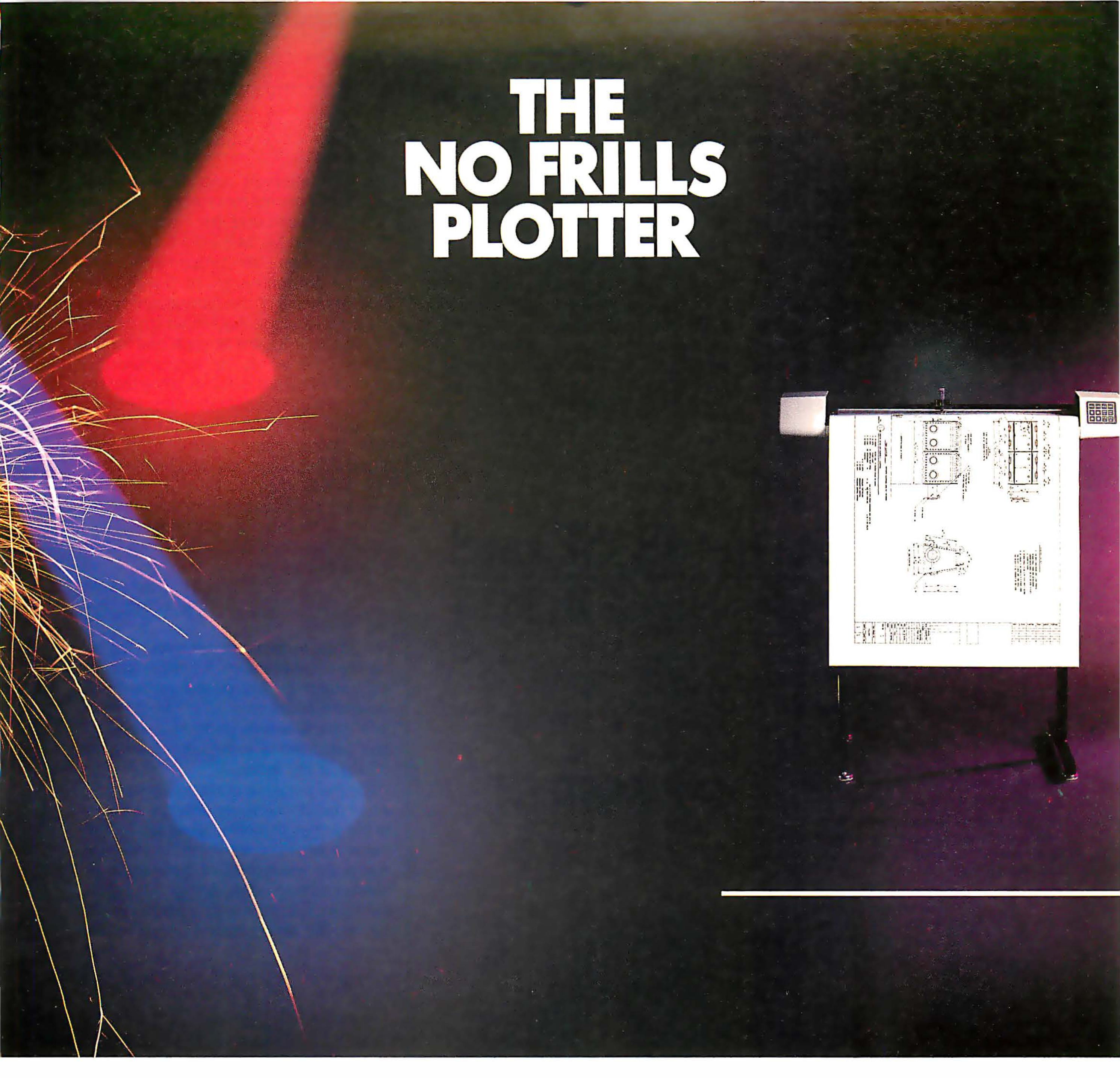
BEN BARLOW
Rochester, NY

CRT Radiation

Regarding the letter by Forrest Mims III in the August BYTE (page 20) where he corrects a previous author's comments about CRT radiation levels: Mr. Mims's work is itself not without fault. I am familiar with some of his previous work and have no quarrel with his hardware expertise; I am sure that he has built a very sensitive radiation detector. However, there is a problem involved in the nature of the measurements he is making.

Measurement of ionizing radiation is a textbook example of a random process. In this case, the random factor is the time between events; thus, in a given time period the number of events (counts of the Geiger counter) is also random. The mathematical properties of phenomena that have random components have been studied for a long time, and in modern times we have a fairly good understanding of them. The twin sciences of probability theory and statistics allow certain types of predictions to be made concern-

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ing the behavior of such phenomena.

In the case at hand, I'm sure Mr. Mims has noticed that, when repeating either of his measurements (background or CRT), the value obtained was not exactly the same each time. This difference is a fundamental property of the nature of the random process being studied. In the case of ionizing radiation measurements, the amount of variation to be expected is a well-known quantity and is described by a mathematical construct called the Poisson distribution.

One of the properties of the Poisson distribution is that the amount of variation you might expect to encounter depends upon the number of events involved. This translates, in the particular case we are discussing, into the fact that the variation in the number of counts per minute decreases as the total measurement time gets longer. Mr. Mims gives no details as to how he made his measurements; therefore, my best guess is that he counted for 1-minute intervals and reported the number of counts measured in that time period. If, in one case, you have measured 17 counts (as Mr. Mims did for the background), then the properties of the Poisson distribution tell us that in other measurements of the same quantity you will get a variation that has an upper limit of just about 35, the count found for the CRT. In other words, Mr. Mims's measurement of 35 counts does not prove that the CRT has higher radiation levels, because he could have gotten the same measurement from a repeat reading of the background! For this reason I find his measurements less than convincing. A much stronger case could be made simply by counting for intervals of several minutes in both cases and calculating the average counts per minute from that data.

HOWARD MARK
New York, NY

Mr. Mark incorrectly assumes that my conclusion that some CRTs can emit ionizing radiation was based on a single 1-minute measurement of two CRTs. In fact, I made several such measurements and reported a representative set of results in my letter.

For the purpose of this reply I placed a commercial radiation counter adjacent to the screen of a color television set and made a series of six 5-minute measurements. Between some of these measurements I monitored the background count for 5 minutes at a point 1 meter from the TV set. The results (counts per 5 minutes) were:

TV On	*TV Off*	*Background*
119	*111*	*72*
122	*108*	*67*
110	*87*	*58*

The averages of these data are 23.4 counts per minute when the TV was on and 20.4 when the TV was off. The background count averaged 13.1 events per minute.

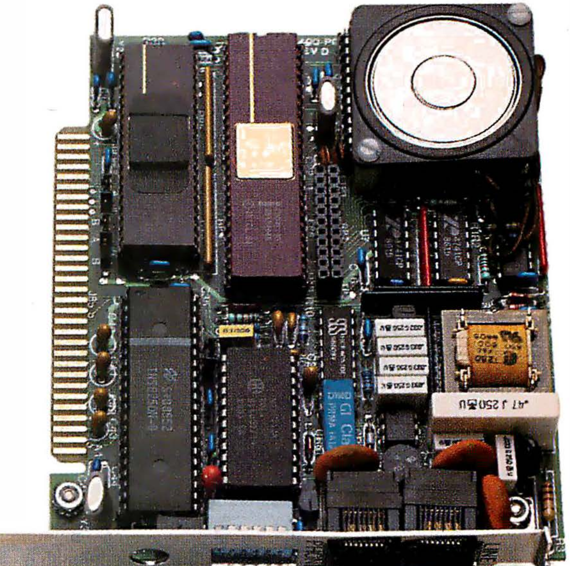
The most interesting aspect of these results is the high count when the TV set is off. Apparently, the CRT or other components of the set are slightly radioactive. My guess is that the phosphor coating behind the faceplate of the CRT is the source. In any event, the conclusion of my original letter that CRTs can emit low but measurable levels of ionizing radiation remains valid.

Readers of BYTE with access to a radiation meter may wish to automate CRT radiation-level measurements. I have described a simple optocoupler interface for a radiation meter and a computer in

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Forrest Mims's Computer Projects *(Osborne/McGraw-Hill, 1985, pages 55–60). I plan to describe a similar technique for long-term radiation measurements in my column in* Modern Electronics.

FORREST M. MIMS III
Seguin, TX

MATHEMATICS OF PROGRAMMING

While Prof. Hoare's objective of applying mathematics of programming (August) is laudable, he starts off on the wrong foot. Many mathematical laws do not apply to truncated or rounded numbers of fixed word length. Consider, for example, the following instance of the associative law (his figure 1), in which the numbers are rounded to two significant figures after multiplication:

$$(.12 \times .95) \times .67 = (.11) \times .67 = .074 \quad (1)$$
$$(.12 \times (.95 \times .67) = .12 \times (.64) = .077 \quad (2)$$

In programming many numerical tasks (for example, finding all of the roots of a polynomial), coping with finite-digit arithmetic is the only nontrivial part of the job.

PHILIP R. GEFFE
Salisbury, MD

COMPATIBILITY—A ONE-WAY STREET

There is one aspect of computer compatibility that appears to have been largely overlooked: the reverse compatibility of the IBM microcomputers with their various compatibles as well as the compatibility of the compatibles with each other. Here is how I came face to face with this problem.

I have recently compiled a GW-BASIC program on a Zenith Z-158 computer using the Microsoft BASIC compiler version 3.02. The compiler created an .EXE file that worked beautifully on the Zenith. However, to my great surprise, when I tried the disk with my .EXE file on IBM, Tandy, NCR, Leading Edge, and Epson computers, the program would not work. In each case the computer returned the message "Cannot execute a child of BASIC." As far as I could ascertain, the only computer other than the Zenith Z-158 on which the program did work was a Hewlett-Packard.

I then compiled the same BASIC program on the Zenith by using the Microsoft QuickBASIC compiler version 2.0. As before, the compiled program worked beautifully on the Zenith and also on the IBM PC. But the IBM PC XT and Epson Equity I would not even read my .EXE file, returning the message "Not ready error reading drive A," although both computers properly showed the disk directory in response to the DIR command (I did not try this compiled program on the other computers).

I then compiled the same BASIC program on the IBM PC XT by using the same Microsoft QuickBASIC compiler. Now the program ran perfectly on the IBM and on all other computers.

Thus, computer compatibility is mostly a one-way affair. The "compatibles" are designed to execute machine-language programs created for the IBMs on the IBMs. But, in general, neither the IBMs nor the compatibles can execute, or even read, machine language programs created on a different machine.

Let this be a warning to those who intend to create IBM software by using a compatible computer. Better make sure beforehand that your intended compatible is two-way compatible.

OLEG D. JEFIMENKO
Morgantown, WV ■

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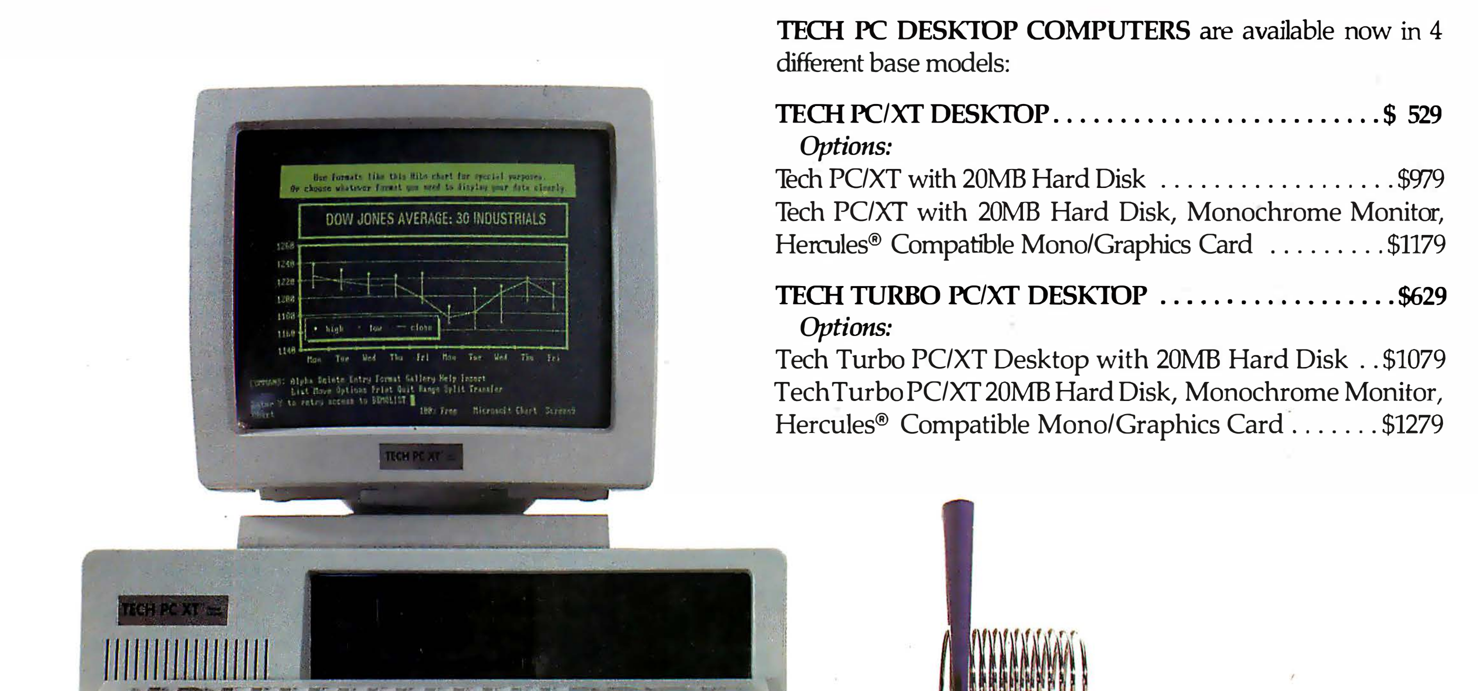
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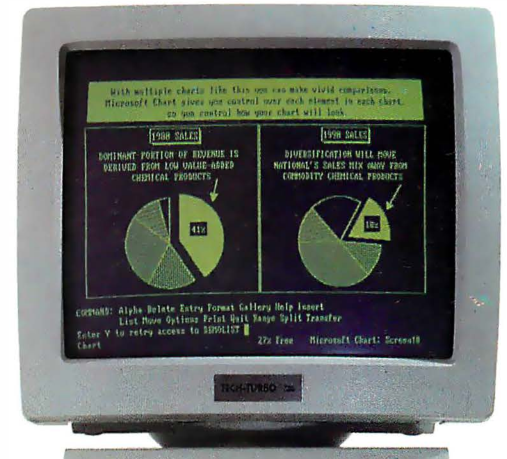
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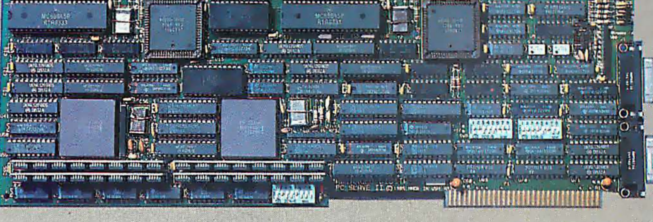
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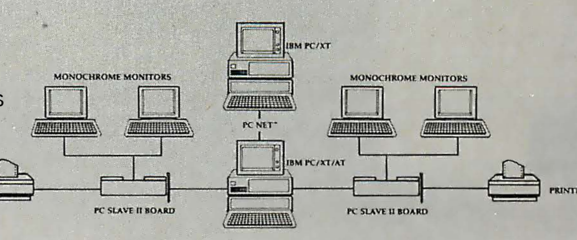


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DEC Introduces VAXmate PC

Digital Equipment Corp. announced the VAXmate computer, an IBM PC AT compatible capable of networking with VAX and MicroVAX computers. At the same time, the company introduced PC All-in-1, a MicroVAX II–based system that can connect up to 30 computers including VAXmates, and VAX/VMS Services for MS-DOS, software that links the VMS and MS-DOS operating systems.

The VAXmate, which runs on an 8-MHz 80286 microprocessor, consists of a system unit with a built-in monitor and 5¼-inch floppy disk drive. The $4045 computer comes with a mouse and a keyboard that supports both DEC and IBM key functions. In addition to MS-DOS 3.1, the system's software includes Microsoft Windows, Microsoft's Networks software, and VT220 and VT240 terminal emulators; the software license costs $250. The networking software and Windows run in the upper 360K of the computer's 1 megabyte of RAM.

The VAXmate is also equipped with an Ethernet transceiver that supports the company's DECnet and ThinWire Ethernet local area network, which transmits information at 10 megabits per second. Via a server, the VAXmate can store and access files on VAX and MicroVAX systems. Besides VAX-based computers, the network can connect DEC Rainbows and IBM PC XTs and ATs running Digital's



DEC's VAX*mate, a networking* AT *compatible.*

DECnet software, as well as IBM mainframe systems linked to the network through DECnet/SNA Gateway software. Network integration kits for IBM PCs and Rainbows will be available in 1987, the company says.

Additional features of the VAXmate include serial and parallel ports and a video controller that supports DEC and IBM graphics modes, including CGA, EGA, and PGA standards. The VAXmate can hold an optional 2-megabyte memory-expansion board ($1600), an internal Hayes-compatible 2400-bps modem ($995), and a math coprocessor ($500). Other options can be added with an expansion box ($1945) that has a 20-megabyte hard disk and two AT-compatible expansion slots.

With PC All-in-1, the VAX mate can access services of DEC's All-in-1 integrated office system, such as document processing and electronic mail. Priced at $81,160, PC All-in-1 contains all the MicroVAX II hardware, software, and services for linking up to 30 computers; several PC All-in-1 systems can also be connected.

Using Microsoft Windows as an interface, VAX/VMS Services for MS-DOS enables PC-compatible computers to store and access information on VAX, MicroVAX, and VAXmate computers acting as servers. With the software, computers can access MS-DOS applications software and files, share laser printers and other peripherals, and access VMS-based files from remote systems on the network. The software ranges in price from $650 to $19,500, depending on configuration; the company plans to offer versions for Rainbows and IBM PC XTs and ATs in 1987.

Digital will also sell server-based licenses for Microsoft's Multiplan, Project, and Chart and Access Technology's 20/20 spreadsheet package. According to DEC, third-party software companies will offer versions of their software for use on the servers.

For more information, contact Digital Equipment Corp., Maynard, MA 01754-2571, (800) 344-4825.

Inquiry 550.

Ashton-Tate Brings dBASE to the Mac

Ashton-Tate introduced dBASE Mac, designed with pop-up menus and dialog boxes to enable you to create and modify the program's data files. A feature called Quick Create provides you with a template for data entry screens and reports, or you can customize the templates with dBASE Mac's graphic layout capabilities.

Using the mouse, you can combine up to 36 data files through common fields. To create custom reports, you can select type styles and sizes, design and draw on the screen, and store and incorporate graphic images.

Software developers can create turnkey applications, including customized alerts and pull-down and pop-up menus. A procedural language includes pre- and postprocessing, add, delete, and write records procedures, if-then statements, and mathematical calculations. A Protect mode prevents you from altering applications.

A 512K Macintosh or a Macintosh Plus, with at least one 800K floppy disk drive, is required. The program costs $495. For more information, contact Ashton-Tate, 20101 Hamilton Ave., Torrance, CA 90502-1319, (213) 329-8000.

Inquiry 551.

(continued)

Works for the Mac

Microsoft Works contains a word processor, database, spreadsheet with graphics, and a communications module. You have the ability to work with up to ten files at once, and Microsoft reports that you can combine information from one module into another with a click of the mouse button.

The word processor has a drawing facility that lets you draw lines, boxes, and circles around or on top of your text. It also has automatic background pagination, a copy format option to copy paragraph formatting from one paragraph to another, and an option for printing mailing labels in custom sizes. With the word-processing module, you also have the ability to create form letters, and text and graphics can be mixed on screen.

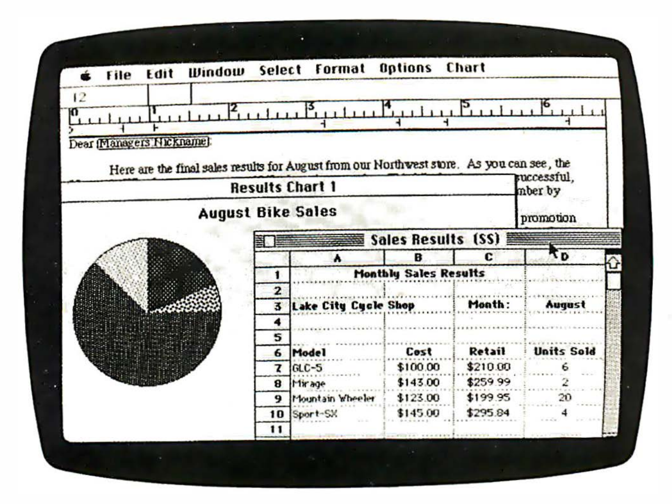
With the database, you can add, delete, or rename fields, and you can store data in up to 60 fields per form.

The spreadsheet has 256 columns and 9999 rows with 54 built-in functions that enable you to perform financial, scientific, or logical calculations. You can also create pie, bar, line, or combination charts for display with data.

The communications module enables you to transmit all spreadsheet, database, and word-processor files without conversion. It also allows you to store up to eight telephone numbers for each document. XMODEM and MacBinary file transfer protocols are supported.

Microsoft Works sells for $295 and runs on a 512K Macintosh or a Macintosh Plus.

For more information, contact Microsoft Corp., P.O. Box 97017, Redmond, WA 98073-9717, (206) 882-8080.
Inquiry 552.



Microsoft Works' word-processing module mixes text and graphics on-screen.

Corvus Announces 80386-based Series

Corvus Systems introduced the Series 386 workstation and 70- and 126-megabyte file servers, all based on Intel's 80386 microprocessor. The machines' 80386 operates at 16 MHz and provides 32-bit memory, two 32-bit expansion bus interfaces for RAM expansion, and enhanced BIOS functions.

The workstation, which is compatible with the IBM PC AT, and file servers come with 512K bytes of RAM on the motherboard and a 16-bit, 2-megabyte RAM expansion board. Each unit can hold six half-height storage devices. Standard features include an AT-compatible keyboard, a 1.2-megabyte floppy disk drive, and a 200-watt power supply. The workstation and lower-capacity file server are equipped with a 70-megabyte hard disk drive with an average access time of 40 ms; the higher-capacity file server uses a 126-megabyte hard disk with an access time of 30 ms. The file servers also incorporate a 60-megabyte streaming tape drive and come with Novell 2.0a software, available in 8086 or 80286 protected-mode versions.

The workstation sells for $12,795; the 70- and 126-megabyte file servers cost $16,595 and $19,795, respectively. The company says that it is working with Award Software of Los Gatos, California, to develop an extended AT-compatible ROM BIOS for use on the Series 386. According to the company, the extended BIOS will take advantage of the 80386's advanced capabilities and maintain compatibility with the 80286 BIOS used in the IBM PC AT. For more information, contact Corvus Systems Inc., 2100 Corvus Dr., San Jose, CA 95124, (408) 559-7000.
Inquiry 553.

SCSI-based Hard Disks for the Mac Plus

General Computer announced an external 20-megabyte hard disk drive, the HyperDrive FX/20, for the Macintosh. The drive uses the SCSI port that's standard with the Macintosh Plus and with upgraded versions of 512K Macs. The drive's data transfer rate ranges from 510K bytes per second to 1.25 megabytes per second (peak). Priced at $1199, the drive includes a print spooling utility that enables you to queue several documents for printing on a LaserWriter while the computer performs other tasks. Also bundled with the drive are a backup utility and a security program that encrypts data in a file and destroys all traces of the original. For more information, contact General Computer Corp., 215 First St., Cambridge, MA 02142, (617) 492-5500.
Inquiry 554.

Supra Corp., manufacturer of the SupraDrive hard disks for the Atari ST computer, also introduced a 20-megabyte external hard disk drive for the Macintosh Plus. The 3½-inch drive connects to the Mac's SCSI port and sells for $799. The drive comes formatted and boots without the use of a floppy disk. The drive's software uses Apple's Hierarchical File System and, the company says, is compatible with all Macintosh applications. For more information, contact Supra Corp., 1133 Commercial Way, Albany, OR 97321, (503) 967-9075.
Inquiry 555.

ProAPP introduced the ProAPP 40S, an external 40-megabyte hard disk drive that connects to the SCSI port on the Macintosh Plus. The drive operates with an average access time of less than 30 ms and is compatible with the original version of the Finder as well as with Apple's Hierarchical File System. Priced at $1995, the drive comes preformatted and with menu-driven installation software. Contact ProAPP Inc., 10005 Muirlands, Suite O, Irvine, CA 92718, (714) 855-9088.
Inquiry 556.

(continued)

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Sperry Introduces Fast AT Clone

Sperry introduced the PC/microIT, a smaller, lower-cost, speeded-up version of the firm's PC/IT. The new machine features a 15-inch-square footprint and five expansion slots, arranged horizontally. Like the older PC/IT, the new computer is manufactured by Mitsubishi but features a slightly faster processor. The PC/microIT's processor runs at a top speed of 8 MHz with no wait states, whereas the older processor has a top speed of 7.16 MHz with no wait states. A standard feature of the computer is support of synchronous communications as well as the more common asynchronous communications. According to Sperry, all one has to do is attach a modem and the appropriate terminal emulation software in order to communicate with various mainframe computers. The system can also be configured to support five users under XENIX System V.

A diskless version of the PC/microIT with 512K bytes of memory and a Key Tronic–type keyboard costs $2345. A version that includes a 20-megabyte hard disk drive, but no floppy drive, costs $3590. A 20-megabyte hard disk card is available for $995, and a 1.2-megabyte floppy drive costs $275. Monitors are additional. For more information, contact Sperry Corp., World Headquarters, Blue Bell, PA 19424-0031, (215) 542-4213 or 542-4217.

Inquiry 557.



Sperry's PC/microIT *runs at a top speed of* 8 MHz

Modular Business Software

Open Access II is a six-function modular business system. The modules include a database with a programming language, spreadsheet, graphics, word processor, communications, and utilities.

The programming language within the database module controls window generation and other screen functions. It uses a free-text format that eliminates line numbers and column restrictions. The database also features global update functions and a status window that shows calculation results as you add, change, or delete records.

With the spreadsheet, a goal-seeking function enables you to define up to five target values, then work backward to perform "what if" calculations automatically. The spreadsheet also features three-dimensional, high-resolution graphics. And you can use the cross-table analyzer to summarize data and incorporate it into specific tables. The spreadsheet also features a text editor, mail-merge and calc-merge capabilities, and the ability to display up to four spreadsheets on-screen simultaneously.

According to the manufacturer, you can use the desktop utilities no matter where you are in the Open Access II system. Utilities include appointment scheduling, a business-card file with autodial, a calculator, alarm, three-time-zone clock, and a calendar.

Open Access II runs on IBM PCs, XTs, ATs, and compatibles with at least 256K bytes of RAM. The program costs $595, and a network version is available for $995. For more information, contact Software Products International, 10240 Sorrento Valley Rd., San Diego, CA 92121, (619) 450-1526.

Inquiry 558.

External RAM Storage for IBM PCs

Santa Clara Systems announced a nonvolatile RAM-based external storage system called BATRAM (short for "battery RAM") for use with the IBM PC and compatible computers. The unit is functionally the same as a hard disk drive although it has no internal moving or mechanical parts. According to the company, the device can transfer data at rates as high as 4 megabytes per second, up to 700 percent faster than hard disk drives. The BATRAM's rechargeable electrolyte gel batteries provide up to two weeks of uninterruptible power so that no data is lost when the system is turned off or power is interrupted. The unit can also be treated as extended memory.

The basic model comes with a 4-megabyte memory board and has four slots available for memory upgrades. The system can be expanded with 4- or 16-megabyte memory cards, to a maximum of 80 megabytes. The unit's interface card plugs into a short slot and supports 8-bit and 16-bit architectures; interrupts and DMA channels are not used. Other features include full error detection and correction capabilities and support for Novell NetWare utilities. The unit also supports all DOS utilities and lets you create and use multiple DOS partitions. The BATRAM's base price is $1895 for a 4-megabyte system; additional 4-megabyte cards cost $1295 each. Memory cards with 16 megabytes of RAM will not be available until next year.

The company also plans to introduce next year optional software that automatically backs up data onto a hard disk connected to the unit. For more information, contact Santa Clara Systems Inc., 1610 Berryessa Rd., San Jose, CA 95133, (408) 729-6700.

Inquiry 559.

(continued)



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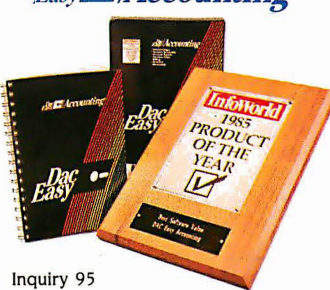
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Compaq Adds Hard Disk, RAM to Deskpro 286

Compaq Computer Corp. announced a new version of the Deskpro 286 that features a 20-megabyte hard disk, 640K bytes of RAM, and a 1.2-megabyte floppy disk drive. The new machine, the Model 20, carries a suggested retail price of $3999. The Model 20 incorporates an 8-MHz 80286 processor and can hold four storage devices. At the same time, the company reduced the price of the Model 1, the earlier version of the Deskpro 286, from $3999 to $2999; the Model 1 has 256K bytes of RAM and a 1.2-megabyte floppy disk drive. For more information, contact Compaq Computer Corp., 20555 FM 149, Houston, TX 77070, (713) 370-0670.

Inquiry 560.

Bubble-Memory Card for IBM PCs

Intel introduced a memory-expansion board for IBM PCs and compatibles that provides up to 1 megabyte of nonvolatile storage. The PC-Bubble Card fits into an expansion slot and emulates the functions of a hard disk drive. According to the company, the card's bubble memory enables it to withstand harsher environmental conditions than traditional hard disk drives.

The card comes with 512K bytes ($895) or 1 megabyte of bubble memory ($1545). It's equipped with a controller, a PC bus interface, PC I/O channel interface logic, and an EPROM-based I/O driver that makes the unit compatible with all versions of MS-DOS and PC-DOS.

An evaluation version of the card is also available and includes software that enables designers to program a bubble-memory controller and build prototype bubble-based systems. A half-megabyte evaluation board costs $495; a 1-megabyte board costs $945. For more information, contact Intel Corp., 3065 Bowers Ave., P.O. Box 85065, Santa Clara, CA 95052-8065, (916) 351-2746.

Inquiry 561.

C++ Translator for the IBM PC

Guidelines Software has released a low-cost C++ translator for the IBM PC family of computers. Developed by Bjarne Stroustrup of Bell Labs, the translator allows you to add features such as object-oriented programming, constructors and destructors, and data abstraction to C programs. The package requires a 640K-byte IBM PC and currently works only with Microsoft's C compiler version 3.0. According to Nathaniel Stitt, a cofounder of the company, Guidelines is currently working on versions for the Lattice and Computer Innovations compilers. The C++ translator sells for $195.

Contact Guidelines Software, P.O. Box 749, Orinda, CA 94563, (415) 254-9393.

Inquiry 562.

Turbo Pascal for the Macintosh

Borland announced that Turbo Pascal for the Macintosh features pull-down menus and dialog boxes. The program makes use of the Macintosh point-and-click interface and the Hierarchical File System.

The company reports compilation speeds of over 12,000 lines per minute. You can create large programs with the feature called Unit Structure, which allows you to link separate units to form one Turbo Pascal program.

Multiple editing windows enable you to edit, compile, and excecute each window individually. You can switch from one window to another with several windows open at the same time.

You also have a choice of how to compile programs, and you can define default volume and folder names for filenames used in compiler directives.

Turbo Pascal for the Mac is not copy-protected. It sells for $99.95 and runs on a Macintosh with at least 256K bytes of RAM and a 400K disk drive.

For more information, contact Borland International, 4585 Scotts Valley Dr., Scotts Valley, CA 95066, (408) 438-8400.

Inquiry 563.

IBM PC Compatibility for the DEC Rainbow 100

Code Blue is a conversion program that transforms the DEC Rainbow 100's operating system into IBM's PC-DOS. Intersecting Concepts, the manufacturer, reports that you do not need to add to or modify the Rainbow's hardware to use Code Blue.

A DEC Rainbow 100 running MS-DOS 2.05 or higher with a minimum of 256K bytes of RAM is required. The company suggests 768K bytes or more for best results.

Code Blue costs $99.95 and is not copy-protected. For more information, contact Intersecting Concepts, 4573 Heatherglen Court, Moorpark, CA 93021, (805) 529-5073.

Inquiry 564.

Develop 68000 Software on IBM PCs

Language Resources has introduced a hardware/software system that enables users of the IBM PC, XT, AT, and compatibles to develop software for the Motorola 68000 processor. The system, called the 68000 SDS, includes a 68000 plug-in board, an in-circuit emulator, and development software. Programs developed on the system can run in any 68000 operating environment, the company claims.

The plug-in board has an 8-MHz 68000 and 512K bytes of zero-wait-state, dual-ported RAM. The board can run user-developed programs in real time or under the control of the symbolic debugger, which provides load, execution, breakpoint, and single-step functions. The debugger also has commands to address, display, and modify memory and registers. The system's in-circuit emulator provides real-time emulation of the 68000 in the target hardware.

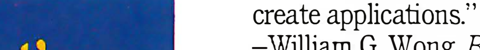
The MASM-68 assembler that comes with the system is a Motorola-compatible assembler incorporating advanced features such as string macros, conditional assembly, structured control, and INCLUDE statements. The system comes with either a C or Pascal compiler, both of which have a run-time interface and floating-point libraries, as well as a linker/locator.

The system sells for $4700. Additional utilities and upgrade options are available. For more information, contact Language Resources Inc., 4885 Riverbend Rd., Boulder, CO 80301, (303) 449-6809.

Inquiry 565.

(continued)

YOU ARE ABOUT TO BE SEDUCED BY POWER AND MONEY.



Admit it. You're intrigued with the idea of C programming. You may be working in BASIC, Pascal or Assembler now. But you're drawn to the power, portability and flexibility of C. And if money is what motivates you, imagine having it all for just $75 with Mark Williams Let's C.®

EVERYTHING YOU COULD ASK FOR IN A C COMPILER.

Let's C is no mere training tool. It's a complete, high quality C compiler. With the speed and code density to run your programs fast and lean. It won't get you sidetracked on some quirky aberration of C; Let's C supports the complete Kernighan & Ritchie C language–to the letter. And it comes from the family of Mark Williams C compilers, the name chosen by DEC, Intel, Wang and thousands of professional programmers.

POWERFUL UTILITIES ARE A REAL BONUS

Let's C doesn't stop with being a high performance C compiler. It includes utilities you'd expect to pay extra for–like a linker and assembler plus the MicroEMACS full screen editor with source code included. Having the source code not only allows you to customize the editor, it offers a close up, fully commented view of C programming at its best.

REVIEWERS ARE SOLD ON LET'S C, TOO.

"Let's C is an inexpensive, high-quality programming package...with all the tools you will need to create applications."
–William G. Wong, *BYTE*, August 1986.

"Let's C is a thoroughly professional C environment loaded with tools and programming utilities...another fine Mark Williams product."
–Christopher Skelly, *COMPUTER LANGUAGE*, February 1986

"The performance and documentation of the $75 Let's C compiler rival those of C compilers for the PC currently being sold for $500... highly recommended..."
–Marty Franz, *PC TECH JOURNAL*, August 1986

Features

- For the IBM-PC and Compatibles
- Fast compact code plus register variables
- Full Kernighan & Ritchie C and extensions
- Full UNIX compatibility and complete libraries
- Small memory model
- Many powerful utilities including linker, assembler, archiver, cc one-step compiling, egrep, pr, tail, wc
- MicroEMACS full screen editor with source
- Supported by dozens of third party libraries
- Upgradeable to C Programming System for large scale applications development
- Not copy protected

Let's C Benchmark Done on an IBM-PC/XT, no 8087.
Program: Floating Point from BYTE, August, 1983.

	Exec Time in Seconds
Let's C	134
MS 4.0	147

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$75
60 DAY MONEY BACK GUARANTEE

ADD THE *csd* DEBUGGER AND CUT DEVELOPMENT TIME IN HALF.

Invest another $75 and you've got Mark Williams revolutionary source level debugger. *csd* lets you bypass clunky assembler and actually debug in C. That's a big help when you're learning C and indispensable when you're programming. *csd* combines the interactive advantages of an interpreter with the speed of a compiler, slicing development time in half. This is how Byte Magazine summed it up: "*csd* is close to the ideal debugging environment." William G. Wong, *BYTE*, August 1986

ARE YOU STILL RESISTING?

If there's any doubt that now's the time to get your hands on the power of C, consider Mark Williams 60-day money back guarantee. You can't lose. But with Let's C and *csd*, imagine what you could gain.

Ask for Let's C and *csd* at your software dealer's, in the software department of your favorite bookstore, through the Express Program at over 5500 Tandy stores or order now by calling **1-800-MWC-1700.***

*In Illinois call 312-472-6659



1430 West Wrightwood, Chicago, Illinois 60614

Inquiry 198

MARK WILLIAMS LET'S C. ONLY $75.

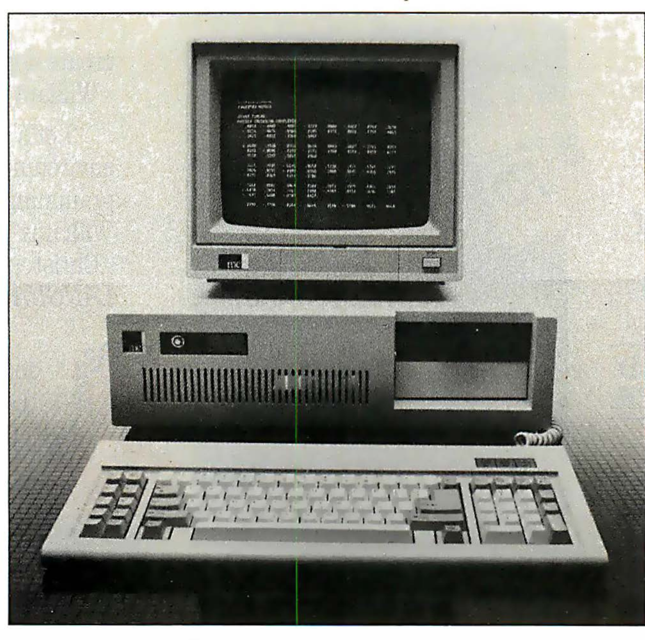
SYSTEMS

MC-32 Personal Supermini

Mighty Computers Co. has introduced its MC-32 Personal Supermini, an IBM PC-compatible computer equipped with a 32-bit coprocessor. The coprocessor board features a 10-MHz 32032 processor with 32-bit data paths and addressing, a 32081 floating-point coprocessor, and 1.5 megabytes of RAM that can be expanded to 8 megabytes. The machine's main processor is an 8088 running at 4.77 MHz.

Under the MS-DOS operating system, the MC-32 runs standard PC-compatible programs. Software development for the 32032 is handled through the host computer. Three high-level languages—C, FORTRAN, and Pascal—are available, in addition to the assembler/linker/debugger/loader software that comes with the computer. An optional virtual I/O package lets developers write code that can occupy up to 15.5 megabytes.

The MC-32 can also run UNIX System V version 5.2. With 1.5 megabytes of RAM and a 20-megabyte hard disk, the system sells for $3500. For more information, contact Mighty Computers Co., 4529 Angeles Crest Highway, Suite 207, La Canada Flintridge, CA 91011, (818) 952-8832.
Inquiry 566.



The dual-processor MC-32 *Personal Supermini.*

Low-Cost AT Clones

HiTech International is offering the SAM 3001, an IBM PC AT compatible, for $995. The computer, manufactured by Samsung, is based on an 80286 running at 6 or 8 MHz and includes 640K bytes of onboard RAM, a 1.2-megabyte floppy disk drive, two serial ports, one parallel port, eight expansion slots, and a color graphics board. An enhanced version, which sells for $1595, is also available. For more information, contact HiTech International Inc., 1180-M Miraloma Way, Sunnyvale, CA 94086, (408) 738-0601.
Inquiry 567.

Computer Direct's CD/286 computer runs on a 10-MHz 80286 processor and offers compatibility with the IBM PC AT. Priced at $1295, the system is equipped with a 1.2-megabyte floppy disk drive, 512K bytes of memory on the motherboard, an AT-style keyboard, and a 192-watt power supply. Various peripherals and add-ins, including monitors, hard disks, and tape backup units, are available as options.

The company's $1795 system includes a Hercules-compatible monochrome graphics card, a monochrome monitor, and a 20-megabyte hard disk. A $2295 system comes with an EGA-compatible monitor and EGA-compatible graphics card with 256K bytes of video RAM. Contact Computer Direct, 7801 North Lamar, Suite E-216, Austin, TX 78752, (512) 459-4199 or 459-4190.
Inquiry 568.

ACP International is selling the Advanced 286, an IBM PC AT-compatible computer that's based on a 6- or 8-MHz 80286 microprocessor. With a price of $1495, the basic system (Model I) comes with 640K bytes of memory on the motherboard, a 1.2-megabyte floppy disk drive, a keyboard, eight expansion slots, a 200-watt power supply, a clock with battery backup, and Phoenix ROM BIOS. The Model II adds a 30-megabyte hard disk drive. Either system can hold three half-height storage devices and use 3½- or 5¼-inch floppy disk drives.

Upgrades and options for the systems are available. Contact ACP International Inc., 1310 East Edinger, Suite C, Santa Ana, CA 92705, (714) 558-8822.
Inquiry 569.

32-bit VME Computer Runs at 25 MHz

Heurikon's HK68/V2F is a 68020-based VME single-board computer designed for real-time applications, including robotics and high-speed communications control. The board features a 68020 processor operating at speeds of up to 25 MHz, up to 4 megabytes of dual-ported RAM, up to 128K EPROM, 128 bytes of nonvolatile static RAM, and an RS-232C serial port; an RS-422 port is an option.

Among the other features of the board are four 8-bit counter timers, mailbox interrupt support, and a master/slave interface to a VMEbus with 32-bit data paths, 32-bit addressing, and single-level arbitration. A 68881 floating-point coprocessor and clock with battery backup are available as options.

The board sells for $1695. It supports Hunter and Ready's VRTX and Microware's OS-9 operating systems. Contact Heurikon Corp., 3201 Latham Dr., Madison, WI 53713, (800) 356-9602; in Wisconsin, (608) 271-8700.
Inquiry 570.

(continued)

MARK WILLIAMS C.
AN ENLIGHTENING DEVELOPMENT FOR ATARI ST USERS.

If you've tried your hand at developing applications on the Atari ST, you know the problem. Programming tools aren't only hard to come by, they're hard to use. One might even say primitive. But now for some enlightening news: you can have all the power, portability and versatility of the C language from a leader in professional C programming tools, Mark Williams.

BRING YOUR PROGRAMMING UP TO SPEED.

The Mark Williams C compiler produces fast, dense code and supports the complete Kernighan & Ritchie industry standard C. You'll have access to GEM's AES and VDI libraries for programs using graphics, icons and the Atari mouse. And Mark Williams C lets you take advantage of the full 16 megabytes in Atari's 68000 microprocessor.

STREAMLINE DEVELOPMENT WITH POWER UTILITIES.

Mark Williams C is loaded with everything you'll need for professional development. Bring the power of the UNIX environment to your Atari ST with our Microshell Command Processor including pipes, I/O redirection and more. Edit your program with the highly acclaimed MicroEMACS full screen editor. Accelerate and simplify compiling with *make* which finds and recompiles only those modules affected by your changes. Then, when you're ready for debugging, call on our db Symbolic Debugger with single step, breakpoint and stack traceback functions. Over 40 commands, including a linker and assembler, provide a total development package for your Atari ST.

Features

C compiler
- Complete Kernighan & Ritchie C plus extensions
- Up to eight register variables
- Full access to AES and VDI libraries for programs using graphics, icons and mouse
- Complete UNIX-compatible libraries allow easy portability to and from UNIX development environment.
- Over 300 Atari-specific routines
- One-step compiling, linking with cc command
- English error messages
- Lint-like error checking

Microshell Command Processor, powerful UNIX style shell includes I/O redirection, pipes, command substitutions

MicroEMACS Full Screen Editor with commented source code included

Make Program Building Discipline

Complete symbolic debugger with single-step, breakpoints and stack traceback

Assembler, linker and archiver

Powerful Utilities Package: egrep, sort, diff, cmp, pr, tail, uniq, wc and more

Over 600 pages of documentation including 120 sample C programs

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$179.95
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Mark Williams C for the Atari ST is part of our growing line of C compilers. A line that includes the C compiler chosen by DEC, Intel, Wang and thousands of professional programmers. Now our Atari C compiler is earning its own reputation:

"Finally a great C compiler that exploits the power of the ST"–Sigmund Hartmann, President, Atari Software Group

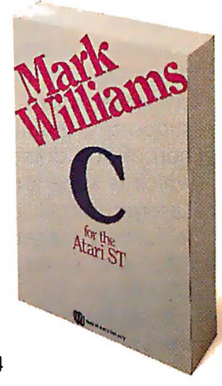
"The all-around best choice for serious software development on the ST."–Douglas Weir of *ANALOG COMPUTING*

GET WHAT YOUR ATARI ST HAS BEEN WAITING FOR.

Mark Williams C is just what your Atari ST was made for: powerful, professional programming. So now that you can have Mark Williams C for just $179.95, what are you waiting for?

Ask your Atari dealer about Mark Williams C or order today by calling **1-800-MWC-1700.***

*In Illinois call: 312-472-6659





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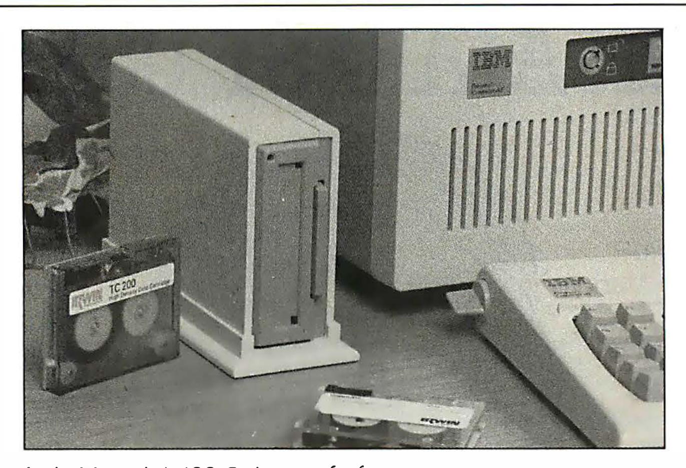
Inquiry 199

PERIPHERALS

Book-size Tape Backup for IBM PCs

Irwin Magnetics introduced its 400 Series Backup tape subsystems for the IBM PC XT, AT, and compatibles. The units come with 10, 20, or 40 megabytes of storage capacity and measure about 2 inches by 7 inches. The 10- and 20-megabyte models for the IBM PC XT and compatibles transfer data at a rate of 250,000 bits per second. The 20- and 40-megabyte models for the PC AT and compatibles feature a data transfer rate of 500,000 bps.

The units have the ability to read tapes created on lower-capacity drives. All models come with a tape cartridge and software; options include an external power supply and cables. Retail prices are $799 for the 10-megabyte model; $950 for the 20-megabyte models; and $1095 for the 40-megabyte model. For more information, contact Irwin Magnetics, 2311 Green Rd., Ann Arbor, MI 48105, (313) 996-3300.
Inquiry 571.



Irwin Magnetics' 400 Series tape backup system.

Add PostScript to LaserJet Printers

The Laser Connection, an affiliate of laser-printer maker QMS, unveiled an add-on for the Hewlett-Packard LaserJet that gives PostScript compatibility to the printer. The $2995 upgrade, called the PS Jet, consists of a top-cover assembly that includes a controller board. The PS Jet supports a graphics resolution of 300 dots per inch, which is superior to normal LaserJet output, and it includes 2 megabytes of RAM and an AppleTalk connection.

In addition to the LaserJet, the unit works with other laser printers based on the Canon print engine. The one-piece unit, the company says, can be installed in a printer in 15 minutes with a screwdriver. Contact The Laser Connection Inc., 7852 Schillinger Park West, Mobile, AL 36608, (205) 633-7223.
Inquiry 572.

AST's TurboScan Digitizes Text, Art

The TurboScan page scanner from AST Research converts color or black-and-white text, art, and photographs into binary code for further processing with a Macintosh or IBM PC and compatible computers. The scanner digitizes images with a resolution of up to 300 dots per inch and uses data compression and DMA transfer to scan an 8½- by 11-inch document in less than 10 seconds, the company says.

The scanner's line-art mode converts images, including those with shades of gray, into black and white. Its halftone mode, which provides 12 screening options, simulates the shades of the original document. You can also mix the two modes when scanning a single image.

The TurboScan, which costs $2395, is equipped with a parallel and a serial port and bundled with software that lets you incorporate scanned images into WordStar documents. Contact AST Research Inc., 2121 Alton Ave., Irvine, CA 92714, (714) 863-1333.
Inquiry 573.

Okidata's Highest-Speed Printer

The Microline 294 dot-matrix printer from Okidata prints at a rate of 400 characters per second in draft mode and at 100 cps in near-letter-quality mode. The printer can also output bit-mapped graphics at a resolution of up to 288 dots per inch.

The 294 comes with one of six plug-in modules that emulate an IBM Graphics Printer or other Microline printers and provide a parallel, RS-232C, or RS-422 interface. Software for type font selection and color printing is bundled with the IBM-compatible module.

The printer can handle continuous forms or cut sheets up to 16 inches wide. An 8K buffer is standard; a 32K buffer is optional. Suggested retail price for the 294 is $1499, which includes one plug-in module; additional modules cost $125 each. Contact Okidata, 532 Fellowship Rd., Mt. Laurel, NJ 08054, (609) 235-2600.
Inquiry 574.

SCSI Tape Backup for Mac Plus

The TDBK-20+, a tape backup unit from MDIdeas for the Macintosh Plus, can back up 22 megabytes of data on each tape cartridge. The unit connects to the computer's SCSI port and works with MDIdeas' HD-20 and HD-30, Apple's Hard Disk 20, and most other hard disks for the Macintosh.

The unit is compatible with Apple's HFS and the original version of the Finder. Suggested retail price is $1095, which includes a 110/220-volt power supply. Contact MDIdeas Inc., 1111 Triton Dr., Suite 205, Foster City, CA 94404, (415) 573-0580.
Inquiry 575.

Test 3½-inch Disk Drives

Proto PC has introduced a 3½-inch adapter kit for its EX2000 Disk Drive Exerciser. When purchased as an option for current models of the EX2000, the adapter kit costs $29 and comes with cables for the connectors on 3½-inch drives. The upgrade kit, sold to owners of older models of the EX2000, costs $49 and includes a ROM upgrade with 3½-inch drive tables in addition to cables. Contact Proto PC Inc., 2424 Territorial Rd., St. Paul, MN 55114, (612) 644-4660.
Inquiry 576.

(continued)



CLIPPER. THE dBASE COMPILER.
A WINNING PERFORMANCE EVERY TIME.

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THE PARACHUTE

ADD-INS

Drive Uses Bubble Memory

The BDH-1 Bubbl-Dek, a solid-state replacement for floppy disk drives, is the same size as a standard full-height 5¼-inch drive and fits in the same mounting holes in an IBM PC or compatible computer. The system provides an average access time of less than 14 ms, the company says, and offers data storage at temperatures ranging from −40° to +80° C.

The unit is available with one or two front-panel slots for plug-in Bubbl-Pac cartridges. A one-slot model costs $1199; a two-slot model, $1689. Each cartridge ($175) provides 128K bytes of nonvolatile storage and measures less than 3 square inches. The cartridges can be write-protected or write-enabled at any time. The drive's data transfer rate is 90,000 bps when used with an external controller and 30,000 bps when used with the optional internal controller.

The unit has five internal slots, three of which can be used for add-on boards, including the optional controller, processors, memory, I/O, and others. For more information, contact Bubbl-Tec, 6805 Sierra Court, Dublin, CA 94568, (415) 829-8700.
Inquiry 577.

Mac Video Adapter

The DVA Composite Video Adapter lets you connect a Macintosh or Macintosh Plus to high-resolution monitors and projectors. The board attaches to the power supply connector inside the Mac and comes with a cable that connects to monitors and projectors.

Packaged with tools and instructions for installation, the board costs $99.95. Also available for use with the adapter is slide show and presentation software that's capable of producing special effects such as block fade. For more information, contact Julian Systems Inc., 4345 Fairwood Dr., Concord, CA 94521, (415) 686-4400.
Inquiry 578.

MIDI Interface for Amigas

The Bright-1 MIDI interface connects MIDI instruments to the Commodore Amiga and works with music software such as Activision's Music Studio.

The $39.95 device attaches via cable to the computer's serial port and provides 5-pin connectors for MIDI-In and MIDI-Out. Its two bicolor LEDs verify proper connection and monitor activity on the interface. Contact Micro Engineering of Northern Virginia, P.O. Box 11780, Alexandria, VA 22312, (703) 750-7860.
Inquiry 579.

Boards Support X.25 Standard

The PCX.2500 series of plug-in boards from EDA Instruments gives users of IBM PCs and compatibles access to digital communications facilities on packet-switching networks, such as Telenet and Tymnet, that use the X.25 protocol. According to the company, benefits of the boards include increased speed, error checking, more reliable communications, and cost savings in some instances.

Two versions of the board are available. The PCX.2501 card interfaces a single computer to a packet-switching network and supports communications at speeds of up to 9600 bps with two logical channels configured. The PCX.2505 card supports a computer and up to four additional devices—including computers, terminals, and printers—and allows them to communicate simultaneously at speeds of up to 9600 bps with six logical channels configured.

Both versions are compatible with communications and file transfer software for IBM PCs, support XON/XOFF or ENQ/ACK flow control, and come with a network management package that provides diagnostic and other capabilities.

Prices for the boards start at $675. For more information, contact EDA Instruments Inc., 4 Thorncliffe Park Dr., Toronto, Ontario, Canada M4H 1H1, (416) 425-7800.
Inquiry 580.

VMEbus/PC AT Adapter

A two-board set from Bit 3 Computer, the 403 IBM PC/AT VME Adaptor, enables the IBM PC AT to act as a VMEbus processor. The boards' address mapping permits the AT to directly address VMEbus memory as though it were AT memory. More than 14 megabytes of VMEbus memory can appear as AT memory. The adapter also enables the AT to control VMEbus I/O devices.

One of the boards fits in a slot in the AT, and the other occupies a slot in the VMEbus card cage. The two are connected by cable up to 50 feet long. The boards support three modes of communication. Direct addressing maps 65K bytes to 14 megabytes of VMEbus memory onto the AT's memory address space. Page-mode addressing permits the AT to control VMEbus memory through a 65K-byte window in the AT's memory address space. Dual-ported RAM-shared memory addressing enables both the AT and VMEbus devices to use the optional dual-ported RAM memory.

The adapter, which sells for $1280, can function as a bus slave, bus master, or one of several bus masters in a multiprocessor VMEbus application. For more information, contact Bit 3 Computer Corp., 8120 Penn Ave. S, Minneapolis, MN 55431, (612) 881-6955.
Inquiry 581.

Graphics Processor for Apples

XOR Systems' Mega-Pix board adds graphics capabilities to Apple IIs. The board contains a 16-bit graphics processor, 128K bytes of RAM that can be expanded to 512K bytes, composite video circuitry, a TTL connector, and an expansion bus for upgrading to color, when available.

Resolution starts at 640 by 200 pixels and can be programmed to 1024 by 1024. To provide a variety of resolutions and configurations, you can add up to six boards to one computer. A graphics software package is bundled with the board.

The monochrome version of Mega-Pix costs $299. For more information, contact XOR Systems, 986 Live Oak Dr., Santa Clara, CA 95051, (408) 249-5388.
Inquiry 582.

(continued)



Fontasy printed all of these.

SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

FORTH Compiler for the Atari ST

Palo Alto Shipping announced the Mach 2/ST FORTH-83 multitasking development system for GEM and non-GEM applications. The system has a text editor, Motorola assembler, symbolic debugger, and floating-point math capability.

The $59.95 Mach 2/ST runs on the Atari 520ST and 1040ST with either a monochrome or color monitor. Other Mach 2 systems are available for the Macintosh and the Amiga. For more information, contact Palo Alto Shipping, P.O. Box 7430, Menlo Park, CA 94026, (415) 854-7994.
Inquiry 583.

C Database Management System Toolkit

Jaybe Software has released Cdb, a C database management system toolkit for UNIX systems. The toolkit comes with 25 programs that you can use alone or with other UNIX tools for developing UNIX applications. Cdb is driven by a dictionary that you set up with descriptions of databases, indexes, and reports. You can then edit and scan the databases, which are made up of variable-length records and allow unlimited fields per record, unlimited records per file, formula fields, and unlimited key fields, according to Jaybe. You can also split or connect databases, or you can run them through filters to create new databases. Cdb supports fixed or floating-point decimal, dollar amount, date, and alphanumeric field types. You can reorganize and restructure records with the index generator and maintain multiple indexes at once.

For security in a multiuser environment, Cdb also features record locking, password protection, and read-only restriction. The toolkit is priced at $495. For more information, contact Jaybe Software, 2509 North Campbell, Suite 259, Tucson, AZ 85719, (602) 327-2299.
Inquiry 584.

LISP Library and C Programming Environment

Clisp is a LISP library and a programming environment for C that runs on IBM PCs, XTs, and ATs. The program contains over 100 functions, including LISP primitives, predicates, and conditionals, a context-sensitive database and stack, and an interpreter to which you can add your own functions. The price of $189 includes source code. Contact Frederick J. Drasch Computer Software, RFD 1, Box 202, Ashford, CT 06278, (203) 429-3817.
Inquiry 585.

dBASE III Plus Compiler

WordTech Systems announced Quicksilver, a dBASE III Plus compiler that features assembly code output, networking, and windowing. You can define your own functions, and you have the ability to link compiled C routines into dBASE applications. The company reports that you also have access to dBASE Tools for C and up to 4000 memory variables.

A set of dBASE-like windowing commands, dB FRAME, is incorporated in Quicksilver. The commands enable you to use source code instructions to create up to 99 active on-screen windows. Quicksilver runs on IBM PCs, ATs, XTs, and compatibles with 256K bytes of RAM and MS-DOS or PC-DOS 2.1 or higher.

The basic Quicksilver package costs $599 and includes the compiler, linker, PC-DOS libraries, debugger, and assembly code translator. MS-DOS libraries are available for $79.

For more information, contact WordTech Systems, P.O. Box 1747, Orinda, CA 94563, (415) 254-0900.
Inquiry 587.

Generate Screens in Any Language

Softway, publisher of the screen generator High Screen, reports that you can design screens in almost any language. When designing with High Screen, you can open windows, display and manage pull-down menus, and manage an on-line help facility. Cursor positioning and management, as well as tests and message displays, are performed by the resident module.

High Screen sells for $199 and runs on IBM PCs, XTs, ATs, and compatibles with PC-DOS or MS-DOS 2.0 or higher. A minimum of 256K bytes of RAM is required. Contact Softway Inc., 500 Sutter St., Suite 222, San Francisco, CA 94102, (415) 397-4666.
Inquiry 586.

SOFTWARE • SCIENTIFIC AND ENGINEERING

Scientific Word Processing

ChiWriter, a scientific word processor from Horstmann Software Design, runs on IBM PCs and compatibles with a minimum of 256K bytes of RAM and a Color Graphics Adapter. The word processor features cut-and-paste, search-and-replace, margin justification, and pagination. The company reports that it can handle up to 20 fonts, which you switch by pressing function keys, and you can use an unlimited number of superscripts and subscripts.

The program is not copy-protected and costs $79.95. For more information, contact Horstmann Software Design, P.O. Box 4544, Ann Arbor, MI 48106, (313) 663-4049.
Inquiry 588.

Schematic Drawings Output to Plotter or Dot-Matrix Printer

HiWIRE is a menu-driven schematic design package that has a library of over 700 common components. Using a mouse, you choose the components, and they are then connected with wires and buses. You can modify the symbols and also create new ones with labels, lines, and arcs. You can output hard-copy schematics to either a plotter or a dot-matrix printer.

To use HiWIRE, you need an IBM PC or compatible with at least 320K bytes of RAM and a Color Graphics Adapter or Enhanced Graphics Adapter. The program sells for $895. For more information, contact Wintek Corp., 1801 South St., Lafayette, IN 47904-2993, (317) 742-8428.
Inquiry 589.

(continued)


C86 PLUS
C COMPILER

SOFTWARE • SCIENTIFIC AND ENGINEERING

Monitor the Wind and Seismic Activity

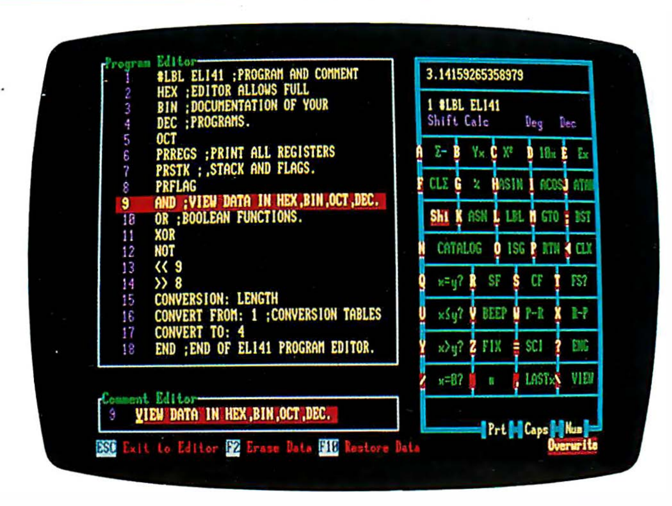
Lbs Engineering announced Lbs-Wind, a wind and seismic analysis program. The program uses wind and seismic building-code data to calculate forces and moments at which they occur. The user can change the data once it is entered into the data file.

Lbs-Wind sells for $19.95 and runs on an IBM PC with at least 96K bytes of RAM and PC-DOS 2.0 or later. For more information, contact Lbs Engineering Inc., 1320 Lincoln St., Hollywood, FL 33019, (305) 920-1584.
Inquiry **590.**

ELI-41 Emulates the Hewlett-Packard 41 Calculator

Eclipse Logic has released the ELI-41 pop-up program that emulates an HP-41. The screen displays the calculator's keypad layout, and all the calculator's functions are included in the program, along with a view of the stack, flags, and registers.

You can program ELI-41 using nested subroutines and an unlimited number of program statements, according to Eclipse. You can also develop conversion tables with standard text editors or word processors.



ELI-41 emulates the HP-41, with the calculator's keypad on-screen.

The calculator functions with 15-digit precision and has binary, octal, decimal, and hexadecimal display and input. There are also 500 registers you can use to store data.

The program is not copy-protected and sells for $74.95. It runs on an IBM PC, XT, AT, or compatible with at least 192K bytes of RAM. A monochrome or color monitor and card are necessary, and you must have MS-DOS or PC-DOS 2.0 or higher.

For more information, contact Eclipse Logic Inc., P.O. Box 2003, Huntington Park, CA 90255-1303, (213) 569-6020.
Inquiry **591.**

Exploring the Fourth Dimension

With 4D Graphics Laboratory, you can rotate and view four-dimensional objects in each of six reference planes—in one frame at a time or all six at once. You can create your own four-dimensional shapes or modify the supplied shapes by controlling the color and position of each line.

The program is written in 8086 assembler and runs on an IBM PC, XT, AT, or compatible with MS-DOS or PC-DOS 2.0 or higher and a Color Graphics Adapter. It costs $44.44. For more information, contact 4D Graphics Lab, 12021 Wilshire Blvd., Suite 537, Los Angeles, CA 90025, (213) 479-4792.
Inquiry **592.**

Perform Statistical Analysis on the Macintosh

Data Desk enables you to interpret statistical relationships by displaying variables as icons. Rotating plots are displayed so you can see the structure of the data, and you can reshape the display to view alternate scalings. It is also possible to compute and display the calculations performed. The program records the date and time that you created or modified a variable, and you can store background information on any variable.

Editing and data entry are performed as word-processing tasks and include searching and replacing. You also have the ability to move data to other Macintosh programs for spreadsheet analysis, word processing, graphical data analysis, and presentation graphics.

Data Desk runs on a 512K Macintosh and sells for $175. A student version is also available. For more information, contact Data Description Inc., P.O. Box 4555, Ithaca, NY 14852, (607) 257-1000.
Inquiry **593.**

SOFTWARE • BUSINESS AND OTHER

Two Desktop Publishers

FTL systems announced MacT$_E$X, a $750 desktop typesetting program that offers hyphenation and justification, kerning, ligatures, automatic pagination, headers, footnotes, and automatic generation of indexes, tables of contents, and bibliographies. There are over 1100 commands and macros, as well as a multiwindow text editor.

MacT$_E$X automatically adjusts the space between words, lines, and paragraphs, so the document fits the page layout. Standard templates for letters, reports, articles, and other types of documents are included, and a single command changes the style of the document. You can create your own macros and libraries of customized page or document styles, and mathematical symbols are available for typesetting.

For more information, contact FTL systems Inc., 234 Eglinton Ave. E., Suite 205, Toronto, Ontario, Canada M4P 1K5, (416) 487-2142.
Inquiry **594.**

You can use memory-resident LaserWare with any application program to produce laser-quality output, according to SWFTE International. LaserWare works with the Hewlett-Packard LaserJet and an IBM PC or compatible. The program's com-

(continued)

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SOFTWARE • BUSINESS AND OTHER

mands operate with all the LaserJet cartridge-based fonts, and you also have the ability to make font changes, center, justify, indent, and set decimal tabs.

Graphics capabilities include capturing graphic plots as they are printed, saving the images to screen, merging graphics directly into text, and printing in variable resolutions.

Forms management features include line and box drawing, shading, and data integration. LaserWare's typesetting capabilities enable you to produce custom forms.

LaserWare sells for $99.95. Contact SWFTE International, P.O. Box 219, Rockland, DE 19732, (302) 658-1123.

Inquiry 595.

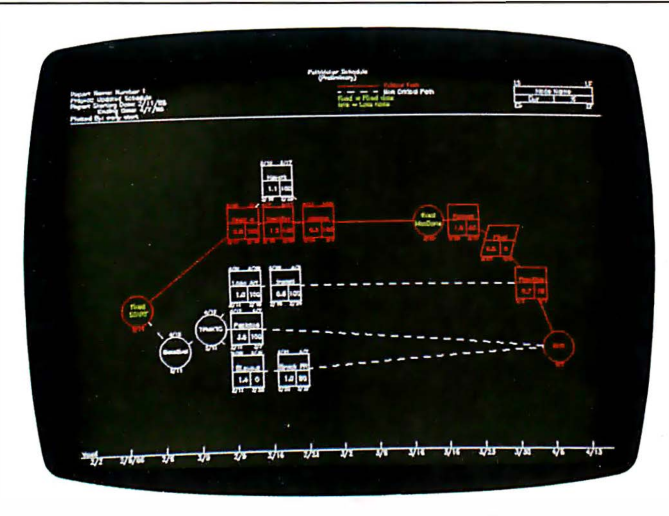
Sales Repeater

Salespeople can keep track of their current customers' buying habits, patterns, and preferences with Sales Repeater's customer database, which stores addresses, phone numbers, and purchase history. Sales Repeater also has a tickler and a business-card file. A search-and-call feature enables you to sort customer files by specific category and create a list of customers who might respond.

The program comes with seven modules directed toward specific industries, and if your industry is not covered, you can use the general module that is available. The utility Call Log Reports produces reports on sales calls. Another utility, Print Menu, produces mailing labels or prints on envelopes.

With Sales Repeater, you can store 300 customer and prospect names per floppy disk and 10,000 on a 10-megabyte hard disk. The program requires an IBM PC or compatible with 128K bytes. The list price is $249. Contact Streamline Software Systems, 14 Perimeter Center E, Suite 1406, Atlanta, GA 30346, (800) 624-5886; in Georgia, (404) 392-9500.

Inquiry 596.



Timepiece, a project management program for the IBM PC.

Amiga Telecommunications

Kent Engineering & Design introduced MacroModem, a telecommunications program for the Amiga. With MacroModem you can create sets of macros and companion help screens. One macro can include up to 35 keystrokes and can load a new set of macros from disk. You can also create files of macros and edit them while on-line.

MacroModem supports the Amiga's windowing environment, enabling you to display your current capture file, read forward or backward, and run the capture file as an independent task in its own window. You can also prepare up to 10 lines of an electronic message in the compose window while the terminal window continues displaying the conference.

You can store up to 36 phone numbers in MacroModem's phone directory, and the program also features auto-dial capability.

An Amiga with 256K bytes of RAM and one disk drive is required to run the program, which sells for $69.95. Contact Kent Engineering & Design, P.O. Box 178, Mottville, NY 13119-0178, (315) 685-8237.

Inquiry 597.

WHERE DO NEW PRODUCT ITEMS COME FROM?
The new products listed in this section of BYTE are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are: (a) does a product match our readers' interests? and (b) is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

Manage Multiple Projects

Timepiece, project management software for the IBM PC family, lets you manage projects, perform "what if" scenarios, create custom calendars for each project, and produce reports in 19 formats. You can also add graphics and sound to reports and output them to printers, plotters, film recorders, and slide-making devices, according to Communication Dynamics.

Timepiece runs on an IBM PC, XT, AT, or compatible with a minimum of 512K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. The company recommends a hard disk, and to produce reports with graphics, you need a graphics display device. The program sells for $695. Contact Communication Dynamics Inc., 7300 Southwest Hunziker, Suite 200, Tigard, OR 97223, (503) 684-5151.

Inquiry 598.

WriteNow

The Macintosh word-processing program WriteNow enables you to do WYSIWYG (what you see is what you get) editing in up to four columns on-screen. You can also insert graphic images in a line of text.

Written in assembly language, WriteNow saves, scrolls, finds, replaces, prints, reformats, and repaginates. There is a 50,000-word spelling checker, and the program handles unlimited headers, footers, and auto-numbering of footnotes, according to T/Maker. WriteNow is priced at $175. Contact T/Maker Co., 1973 Landings Dr., Mountain View, CA 94043, (415) 962-0195.

Inquiry 590.

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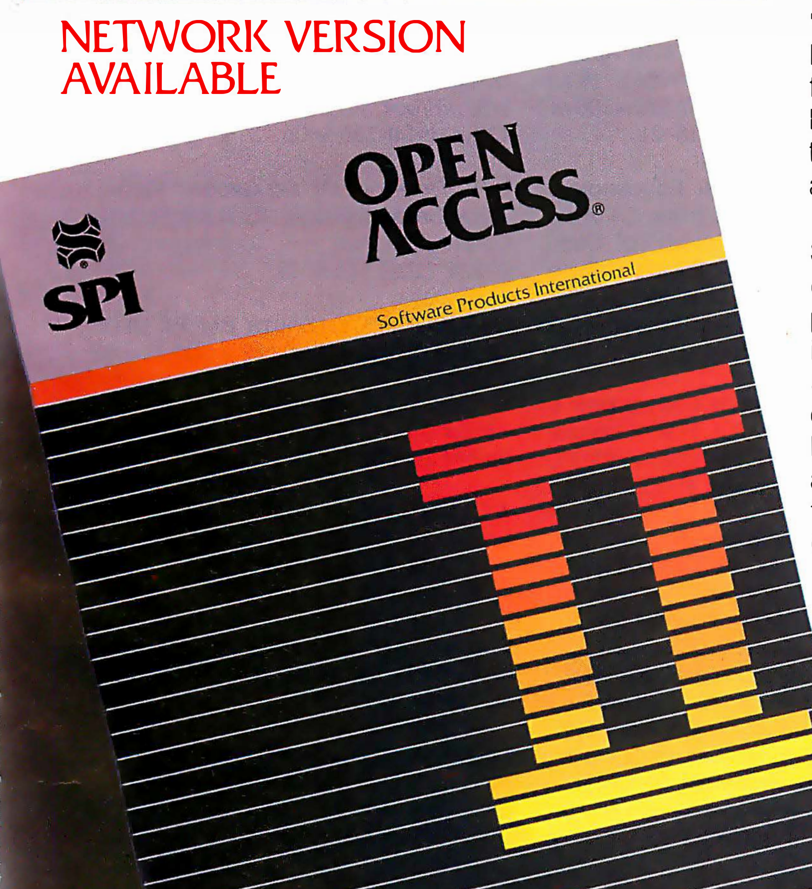
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Lotus 1•2•3	✓					✓		✓					495.00
Symphony	✓	✓	✓			✓		✓		✓	✓		695.00
Framework	✓		✓	✓		✓		✓		✓	✓		695.00
Enable	✓		✓			✓	✓	✓		✓	✓		695.00
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November 1986

EVENTS

EXPLORING THE KNOWLEDGE-BASED SOCIETY: ASSOCIATION FOR COMPUTING MACHINERY–IEEE COMPUTER SOCIETY 1986 FALL JOINT COMPUTER CONFERENCE (FJCC '86), Dallas, TX. Dr. Stanley Winkler, FJCC '86, 1730 Massachusetts Ave., Washington, DC 20036-1903, (202) 371-0101. *November 2–6*

THE COMMUNICATIONS CONNECTION, Portland, OR. Terrie Walker, Telecommunications Association, Portland Community College, 12000 Southwest 49th Ave., Portland, OR 97219. *November 3–5*

ELECTRONIC IMAGING '86, Boston, MA. Electronic Imaging '86, Institute for Graphic Communication Inc., 375 Commonwealth Ave., Boston, MA 02115, (617) 267-9425. *November 3–6*

IMPLEMENTING CLINICAL COMPUTER SYSTEMS, Phoenix, AZ. American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103, (215) 299-5526. *November 5–6*

COMPUTER SECURITY AND ACCESS CONTROL, Milwaukee, WI. Peter L. Tocups, Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 North Sixth St., Milwaukee, WI 53203, (414) 224-3952. *November 5–6*

SCIENTIFIC COMPUTING & AUTOMATION CONFERENCE AND EXPOSITION, Atlantic City, NJ. Expocon Management Associates Inc., 3695 Post Rd., Southport, CT 06490, (203) 259-5734. *November 5–7*

NORTH AMERICAN TELECOMMUNICATIONS ASSOCIATION CONVENTION & EXHIBITION SHOWCASE (NATA 86), St. Louis, MO. North American Telecommunications Association, 2000 M St. NW, Suite 550, Washington, DC 20036. *November 5–7*

ASSOCIATION FOR THE DEVELOPMENT OF COMPUTER-BASED INSTRUCTIONAL SYSTEMS 28TH INTERNATIONAL CONFERENCE, Washington, DC. Gordon Hayes, ADCIS, Miller Hall Room 409, Western Washington University, Bellingham, WA 98225, (206) 676-2860. *November 10–13*

COMDEX/FALL '86, Las Vegas, NV. The Interface Group, 300 First Ave., Needham, MA 02194, (617) 449-6600. *November 10–14*

PC FAB EXPO '86, Long Beach, CA. PMS Industries, 1790 Hembree Rd., Alpharetta, GA 30201, (404) 475-1818. *November 11–12*

WINTER NATIONAL DESIGN ENGINEERING SHOW, San Francisco, CA. Winter National Design Engineering Show, 999 Summer St., Stamford, CT 06905, (203) 964-0000. *November 11–13*

EDUCOM '86, Pittsburgh, PA. EDUCOM, P.O. Box 364, Princeton, NJ 08540, (609) 734-1888. *November 11–14*

SIXTEENTH ANNUAL MEETING OF THE SOCIETY FOR COMPUTERS IN PSYCHOLOGY, New Orleans, LA. Cyndi McDaniel, Psychology Department, Northern Kentucky University, Highland Heights, KY, 41076, (606) 572-5310. *November 12*

TOOLS FOR RENDERING 3-D IMAGES, RECURSION IN COMPUTER GRAPHICS, AND COMPUTER GRAPHICS IN THE CLASSROOM, New York University, New York, NY. Gideon Nettler, 80-40 Lefferts Blvd., Kew Gardens, NY 11415, (718) 849-6313. *November 17*

WESCON/86, Anaheim, CA. Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, (800) 421-6816; in California, (800) 262-4208 or (213) 772-2965. *November 18–21*

TENTH ANNUAL WESTERN EDUCATIONAL COMPUTING CONFERENCE, Irvine, CA. Alexia Devlin, California Educational Computing Consortium, San Francisco State University, Accounting Data, NADM-358, 1600 Holloway Ave., San Francisco, CA 94132. *November 20–21*

EIGHTH ANNUAL FORTH CONVENTION & BANQUET, Santa Clara, CA. FORTH Interest Group, P.O. Box 8231, San Jose, CA 95155, (408) 277-0668. *November 21–22*

FORTH MODIFICATION LABORATORY (FORML), Pacific Grove, CA. FORTH Interest Group, P.O. Box 8231, San Jose, CA 95155, (408) 277-0668. *November 28–30*

If you send notice of your organization's public activities at least four months in advance, we will publish them as space permits. Please send them to BYTE (Events and Clubs), One Phoenix Mill Lane, Peterborough, NH 03458.

CLUBS

INTELLOG ASSOCIATION FOR THE APPLICATION OF ARTIFICIAL INTELLIGENCE, 85 rue du Fbg. St. Denis, 75010 Paris, France.

STM USERS GROUP (Not affiliated with STM Corp.), 3778 Hitching Post Road, Jackson, MI 49201, (517) 782-2297.

ZSIG (Z-SYSTEM SPECIAL INTEREST GROUP), Michael Broschat, 2610 East Aloha, Seattle, WA 98112, (206) 328-0561.

MESA (MACINTOSH ENTHUSIASTS OF SAN ANTONIO), J. Eddie Field, Rt. 4, Box 2151, Lakehills, TX 78063, (512) 751-2947. (They are also seeking exchanges with other Mac users groups.)

PC WORD PROCESSING NEWSLETTER, Leo Dmitri, 60 West 10th St., New York, NY 10011.

NEW HAVEN ST's, Robert Fischer, 80 Killdeer Rd., Hamden, CT 06517, (203) 288-9599. (Atari ST users group.)

NORTH AMERICAN AMSTRAD USER SUPPORT GROUP (NAAUSG), Sage Enterprises, Rt. 2, Box 211, Russellville, MO 65074.

AMIGA USERS GROUP/HUDSON VALLEY (AMICUS/H.V.), Ralph Blanchette, Box 327 Willowbrook Rd., Clinton Corners, NY 12514, (914) 266-5606.

H/P DESKTOP USERS GROUP, METRO AREA, Bruce E. Baxter, IRS D:R:R:M, 1111 Constitution Ave. NW, Washington, DC 20224, (202) 566-6759.

GSBUG (GREATER SOUTH BAY PC USER GROUP), P.O. Box 1937, Redondo Beach, CA 90278.

AMIGA GURU, CA-AUG, 3715 Townley Rd., Shaker Heights, OH 44122.

A.L.I.E.N. (ATARI LOVERS OF ILLIANA EQUAL TO NONE), Richard Thompson, 7609 Jarnecke Ave., Hammond, IN 46324 (219) 932-2866.

DENVER AREA TRS-80 ASSOCIATION (D.A.T.A.), Frank Berndt, 1799-D South Lee St., Lakewood, CO 80226, (303) 989-6068.

COCO CARTEL, A COLOR COMPUTER USERS GROUP, Dennis Weldy, 4059 Acacia Dr., Columbus, GA 31904. ■

Conducted by Steve Ciarcia

ENCODING A KEYBOARD

Dear Steve,

Can you tell me how to encode an unencoded keyboard? I have a surplus keyboard from a Coleco Adam that I would like to use in building the Term-Mite smart terminal (January and February 1984 BYTE). I need to know how to produce the parallel data needed by the Term-Mite board from the keyboard matrix. I have the pin-out diagram that shows which intersection corresponds to which key. Is there a chip that performs the encoding automatically, or do I have to work out my own logic?

MARK T. JOHNS
Naperville, IL

There are a number of ways to encode an unencoded keyboard. All of the methods generally rely on a scanning technique so that when a keypress is generated, the circuitry senses this and reports the address of the key. Usually, debouncing of the switches is done to improve the reliability of the encoding.

A chip that is readily available and "does it all" is the KR-3600-Std (also an AY-5-3600) and is intended for a 90-key keyboard, something like the keyboard you mentioned. You can buy one of these from

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
(415) 592-8097

You can also purchase a data sheet from them for this chip for 50 cents, which I highly recommend.—Steve

ONE THING AT A TIME

Dear Steve,

Here's a software problem that gets down to hardware constraints: Can an IBM PC's (or PC XT compatible's) disk drives be used in I/O interrupt mode? I have often wished that I could run programs concurrently with I/O processing. Although MS-DOS does not support multitasking, the PC's hardware does provide interrupt capability and has DMA (direct memory access) circuitry.

A simple algorithm featuring "double-buffered" I/O would allow a program to use one buffer while the disk driver software is filling or emptying the other. The completion of the two processes could be synchronized and the role of the two buffers could be switched so that I/O would take place continuously. Are there any disk drivers available for the PC that start an I/O operation, return control to the calling program immediately, and then signal completion at a later time?

GREG DENTON
San Jose, CA

It is possible for you to run the disk drives using DMA and interrupts, but you'll gain no practical advantage. The reason, as you have already stated, is that DOS does not support multitasking. The implications of this are more restrictive than you imagine. Let's suppose you add overlapped I/O without changing anything else.

Consider what happens if a program writes two buffers of data to disk. It issues a write request for the first buffer, DOS starts the I/O operation, and control returns to the program while the data is being transferred. The program issues the second write request, DOS puts the new request into a queue because the first one isn't done yet, and control returns to the program again.

Now, if a glitch occurs, the data in the first transfer is corrupted. DOS knows that there has been an error, but how does it signal the program that all is not well? The two write requests were issued in the past, and the program is off and running something else.

Of course, if you write the program and the disk driver together you could make it work the way you want, but then your system isn't MS-DOS-compatible. The Fastback hard disk backup program works this way. Its authors wrote a special device driver for the floppy drive that bypasses DOS and uses DMA data transfers with interrupts to stream data onto the floppy. The resulting disks can't be read by DOS, but the program is the fastest disk backup utility around.

Oddly enough, the device driver program format used by PC-DOS and MS-DOS has two entry points called STRATEGY and INTERRUPT, which are obviously designed for use in a multitasking interrupt-driven system similar to the one we'd both like to have. The current versions of DOS fake a device interrupt and enforce the single-threaded method of handling devices, but at least there's hope.—Steve

DISABLING AUTO-REPEAT

Dear Steve,

I want to disable the automatic-repeat feature of the keyboard on an Apple IIe. My objective is to make the machine easier to use for people with poor manual dexterity (cerebral palsy). The IIe was recommended because of its expansion slots that allow for special peripherals.

I asked a local Apple repair department how to disable the auto-repeat feature, and the responses I got included "It can't be done" and "It can only be done by changing a ROM, but we don't know how you could get the right ROM."

I looked at the Sams Computerfacts schematics and troubleshooting information for the IIe and it appears that capacitor C70 and resistor R32 are involved in the auto-repeat function. It looks like C70 charges or discharges through R32 and thus generates a time delay that is used by the decoder chip E14. I don't have enough information to know exactly what to do; a technician at an Apple dealer suggested removing C70, but my theory is that putting a resistor in parallel with C70 would be better.

(continued)

IN ASK BYTE, *Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to*

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Due to the high volume of inquiries, personal replies cannot be given. All letters and photographs become the property of Steve Ciarcia and cannot be returned. Be sure to include "Ask BYTE" in the address.

The Ask BYTE staff includes manager Harv Weiner and researchers Eric Albert, Bill Curlew, Ken Davidson, Jeannette Dojan, Jon Elson, Roger James, Frank Kuechmann, Dave Lundberg, Edward Nisley, Dick Sawyer, Andy Siska, and Robert Stek.

MICROSOFT LANGUAGES NEWSLETTER Vol. 1, No. 11

News about the Microsoft Language Family

Compiling Efficiently with Microsoft® QuickBASIC

Microsoft QuickBASIC Version 2.0 offers you a wide range of choices when you compile. You can compile programs directly into memory, or create executable programs on disk depending on your needs. To get the most out of the compiler, you should know the various size/speed tradeoffs associated with each compile option.

In-memory compilation places an executable file directly into memory from the Microsoft QuickBASIC programming environment. This is the easiest way to compile and run Microsoft QuickBASIC programs during program development. The advantage of this method is that it allows you to compile and run without leaving Microsoft QuickBASIC. However, the program can only be executed from inside the Microsoft QuickBASIC programming environment.

You can also use Microsoft QuickBASIC to create an executable file on disk that can be run without entering the programming environment. There are two different kinds of stand-alone executables: programs that include the run-time environment in the .EXE file and programs that require the presence of the run-time module BRUN20.EXE when run.

The .OBJ(BCOM.LIB) or /o option creates an object file that when linked to the BCOM20.LIB library becomes a program that runs without the presence of the run-time module BRUN20.EXE. Programs linked with the BCOM20.LIB are larger, but execute much faster than programs that require the run-time module. Besides execution speed, the advantages of this method are that the program does not require an additional file to run and the program can be conveniently copied to other disks.

The .OBJ(BRUN.LIB) option creates an object file that when linked to the BRUN20.LIB library requires the presence of the run-time module BRUN20.EXE to execute. Programs linked with BRUN20.LIB are smaller, but run slower than programs linked with BCOM20.LIB. The speed degradation results from the fact that BRUN20.LIB uses software interrupts to call the run-time routines, whereas BCOM20.LIB uses direct calls. The Speed or /q option explained below can minimize this difference. Depending on your size and speed requirements, you should probably link with BCOM20.LIB if you are distributing only one program, or if the user might copy the program to another disk without also copying the run-time module. If your application chains programs, or your distribution will include several programs, you should link with BRUN20.LIB and distribute BRUN20.EXE with your programs. There are no licensing requirements and no fee for distributing the BRUN20.EXE run-time module.

The .EXE option creates an executable program on the disk. This program requires the presence of BRUN20.EXE to execute.

The Debug or /d option should be used in debugging your program during development. It generates larger and slower code by including debugging and error handling code in the executable program that checks for arithmetic overflow/underflow, array bounds and the existence of GOSUBs with each RETURN statement. When the program is completely debugged and ready for distribution, you will want to compile the program without this option to maximize speed and minimize size.

You must use the On Error or /e option in programs that contain ON ERROR GOTO and RESUME *linenumber* statements. This option creates a larger program (by building a table of entries for each line number). Use the Resume Next or /x option in programs that contain RESUME, RESUME NEXT, and RESUME 0 statements. Compilation takes longer and results in larger object files than the On Error or /e option because it increases the table of line number entries.

The Checking Between Statements (/v) and Event Trapping (/w) options enable event trapping for communications, lightpen, joystick, timer and function keys. Both of these options increase code size and slow execution. The Event Trapping (/w) option checks between lines for the occurrence of an event and takes less space and execution time than /v.

The Speed or /q option optimizes the programs compiled using BRUN20.LIB to be nearly as fast as programs compiled using BCOM20.LIB, but results in a larger executable because every call has two bytes more overhead. If you do not specify this option, the program will be as small as possible but the execution speed is slower than if you specified /q. The size and speed effects of this option depend on the number of repeated statements in loops you use in your program.

If you are compiling in memory and you are getting "Out of Memory" errors, you may want to use the Minimize String Data or /s option. This option writes quoted strings to the .OBJ file instead of the symbol table. This allows you to compile a large, string-intensive program without getting "Out of Memory" errors when compiling in memory, but it increases the size of the .OBJ file. De-selecting the Debug option may also solve out of memory problems in large programs.

For more information on the products and features discussed in the Newsletter,
write to: Microsoft Languages Newsletter
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Look for the Microsoft Languages Newsletter every month in this publication.

I would greatly appreciate any assistance you could give us in solving this problem; I'm sure that many handicapped users of the IIe would be interested in a solution to "unwanted auto-repeat."

THOMAS K. JOHNSON
Crystal Lake, IL

Capacitor C70 and resistor R32 in the Apple IIe keyboard circuit are part of the oscillator that causes the decoder IC to scan the keyboard. They have nothing to do with the keyboard auto-repeat function. Altering the values of either will do nothing but damage, and if you remove either, the keyboard encoder will cease functioning.

The auto-repeat feature of the Apple IIe is located in a custom IC called the "IOU" chip on the motherboard. You would have to replace this chip in order to disable the function, but there is nothing available to replace it with. Consequently, there is no reasonable way to disable this feature.—Steve

COMPAQ RESET SWITCH

Dear Steve,

I am interested in adding a reset switch to my Compaq Portable. I would appreciate it if you could show me a schematic of such a circuit. Such a switch would prove invaluable, especially when debugging assembly language programs that invariably freeze up the computer. I understand that grounding the microprocessor's RESET pin does not result in a complete reset.

RICK RETTER
Danbury, CT

There is more to resetting a computer than grounding the RESET pin on the CPU chip. If you want to find out where your code is hanging, you need to do something more sophisticated.

Grounding the RESET pin on the CPU will initiate the memory test routine—thus erasing the code you are trying to debug—and then go about the process of restarting DOS. This will probably get the computer back up and running, since most of the resetting of the hardware is done by ROM code. It would be nicer if you could get into a debugger program while the system is hung.

Unfortunately, the 8088 does not have many features to protect the monitor, debugging facilities, and interrupt vectors from damage done by a runaway program. So, if these areas are damaged, a reset through a software vector to a debugger would be useless anyway. There are several reset cards on the market, but I cannot say with confidence that any particular one will work on the Compaq (although they all should). Still, the problem of code damage may make these cards less than perfect.

To reset the CPU, you need to follow the signal back from the CPU RESET pin (pin 21) to the device that drives it. It will have an RC timing circuit attached that applies a proper RESET signal level for a time after the power comes on. Grounding this circuit with a push-button switch will reset the processor; but, as I have said, you will lose all history of what went wrong.—Steve

READING CATALOG INTO ARRAY

Dear Steve,

I would like to be able to read the contents of a DOS 3.3 disk catalog into an array, so that the name of every text file (file type "T") on the disk is loaded into its own

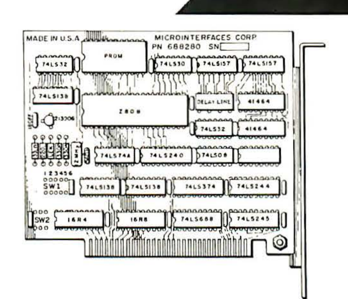
(continued)

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A typical DBMS user's screen, after the 497th line of code.

```
SELECT ALL FROM callrpt SORTED BY calldate WHERE,...

—Choose an operator to combine conditions—Choose (Done) when done—
   AND   OR   AND   NOT   OR   NOT   (Done)
```

	Column	Operator	Value
	district	EQ	Boston
OR	district	EQ	New York
AND	calldate	GT	March 12, 1985
AND	comment	contains	American Baking Company

An R:BASE System V Prompt-By-Example (PBE) screen. With PBE's query capabilities, you can retrieve just the information you need. Without programming.

Aunt Betty's Baked Goods

Transaction date: 6/25/86
Trans ction number: 4609
Customer number: 666

Date: 6/25/86

Name: Speedy Shopper, Inc.
Address: 4092 Industrial Way
City, State, Zip: Dryden, New York 13053
Phone: 800-555-0661

Stock #	Brand	Qty.	Price	Extended Price
207	Bake-A-Batch Cookies	93	2.00	186.00
308	Peanut Butter Crunch	100	2.50	250.00
619	Double Rich Brownies	150	4.95	742.50

A data entry screen designed without programming, using Forms EXPRESS.

With most database management software for the IBM PC family and compatibles, you're quickly confronted with a painful reality: the only way to make your package live up to its promise is to learn its programming language. Which can take months. Then you have to write the code, line after frustrating line.

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Of course, with R:BASE System V, you can enter, query, and report on data in a non-automated, ad hoc fashion. Without programming. And there's a high-level procedural language for programmers. But that's just the beginning.

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With the EXPRESS System in R:BASE System V, you can access powerful features, without programming, that other data management software can't touch.

With Definition EXPRESS, you can build a database structure with advanced features like computed columns, and *searchable* note fields. VIEWS that combine up to five tables in a single, powerful table. Data validation rules that check incoming data for errors. All without programming.

Then you can use Forms EXPRESS to create customized data entry forms. The forms you create can load data into five different tables, linked in One-To-Many relationships. You can also include scrolling regions, custom borders, and custom colors, all without programming.

And with Reports EXPRESS, you can design reports exactly the way you want. And see what they'll look like, right on the screen. To see how complex your reports can be, take a close look at the example at the end of this page.

Finally, you can tie it all together with Application EXPRESS. First, you design your own multi-level system of menus. Your first menu level might look like this:

```
Aunt Betty's Sales Reporting System
   (1) Enter Sales Data
   (2) Edit Sales Data
   (3) Print Daily Sales Report
   (4) File Processing
   (5)Exit
```

For each menu choice, you assign an action. For example, to define menu choice #3, choose the action "PRINT," select the report you just created in Reports EXPRESS, and specify the appropriate data sorting and selection criteria. Then Application EXPRESS automatically writes the program code.

Which means you've just created a very sophisticated program to deliver the full power of your DBMS. And you've done it all without learning how to program. From this point on, every time you want to run a report, all you do is choose item #3. With one simple keystroke, you've got it.

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If you're an experienced programmer, you can use R:BASE System V to tackle the most demanding applications. You can use Application EXPRESS to create prototypes faster than with any other microcomputer-based DBMS.

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DBMS PROGRAMS
RFUL DBMS PAIN.

keeps track of the action. Automatically.

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Page: 1
Date: Tuesday, June 24, 1986
Time: 8:00 am

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Aunt Betty's Baked Goods, Incorporated
California Division
Daily Sales Report
For June 23, 1986
Confidential Information

Four levels of grouping... (Up to 10 levels possible)

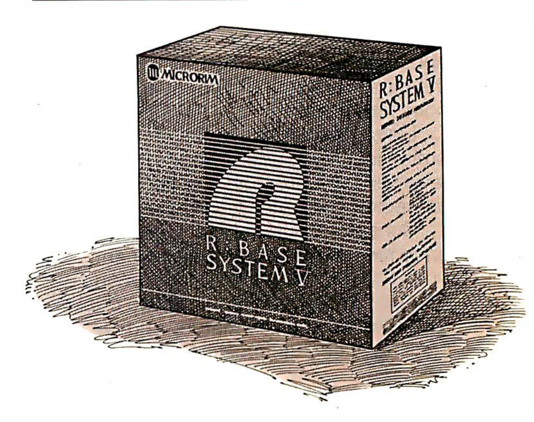
1 Q1-1986
2 Southern California
3 Cracker Products
4 Wheat Crisps
Rye Crackers

	TOTAL SALES
Wheat Crisps	97,536.22
Rye Crackers	235,223.11
Total Cracker Product Sales	332,759.33
Sweet Goods Products	
Bake-A-Batch Cookies	25,006.23
Peanut Butter Crunch	8,623.30
Coconut Macaroons	19,446.90
Double Rich Brownies	113,636.01
Total Sweet Goods Product Sales	166,712.44
Total Sales, Southern California	499,471.77
Northern California	
Cracker Products	
Wheat Crisps	57,406.25
Rye Crackers	175,223.56
Total Cracker Product Sales	232,629.81
Sweet Goods Products	
Bake-A-Batch Cookies	45,146.55
Peanut Butter Crunch	47,123.80
Coconut Macaroons	9,390.99
Double Rich Brownies	517,446.25
Total Sweet Goods Product Sales	619,107.59
Total Sales, Northern California	851,737.40
Total Sales	1,351,209.17

Prints summary line for grouping

Draws boxes anywhere in report

A program to print this report daily, with a one-keystroke menu pick, was developed without programming using R:BASE System V's EXPRESS Technology. Whether you know how to program or not, R:BASE System V is the shortest distance to your data management solution.



NEW R:BASE SYSTEM V
FROM MICRORIM

array entry. I have tried a number of ways to do this, but to no avail.

DAVID FREIBRUN
Los Angeles, CA

Call—A.P.P.L.E. in Depth, Number Three: All About DOS *(A.P.P.L.E. Co-op, 290 SW 43rd St., Renton, WA 98055) contains a program that will read a disk catalog into an Applesoft array. Using it as a starting point, you should be able to create the program you want.*—Steve

CIRCUIT CELLAR FEEDBACK

VOICE RECOGNITION TECHNOLOGY IN DENTAL RESEARCH

Dear Steve,

I am the director of a clinical research group in Boston. Our work includes the testing of diagnostic methods for early signs of periodontal (gum) disease. Although several methods being tested can be interfaced to a computer (e.g., temperature, tooth mobility, and periodontal pocket depth), inevitably we are faced with the need to compare results with older, subjective rating schemes. Thus, voice recognition becomes a technology worth considering.

My principal concern is the expected error rate of this methodology. Although the vocabulary requirements are small, our current methods achieve error rates on the order of 1 in 1000 or better and we would not consider 1 in 100 acceptable. I don't know the expected error rate of current voice recognition technology.

The problem I am describing is general for clinical research. Classically, a second individual is employed to write verbal information (usually numbers) on a piece of paper, so the design of a total computer interface environment creates the potential for single-clinician diagnosis, thereby multiplying productivity.

I would appreciate your thoughts on the practicality of conducting clinical experiments using voice recognition and if you think it practical, could you recommend specific hardware and software to accomplish this task.

J. MAX GOODSON, D.D.S., PH.D.
Department of Pharmacology
Forsyth Dental Center
Boston, MA

While voice recognition is indeed a viable method of accomplishing your needs for data collection, the level of accuracy you're looking for is dependent on a number of factors both inside and outside the system you choose to do the recognition.

Hobby-style boards typically achieve successful recognition rates in the 95 to 99 percent range at best with vocabularies of 30 to 60 words. Room noise is a factor, as are variations in voice. Usually, a system is "trained" to recognize a specific individual, so that every time a new researcher uses it, retraining is required for full recognition.

To achieve the error rates you indicate, even with the low vocabulary, would require a relatively expensive system. On the other hand, I can think of other ways to accomplish the same thing with no errors associated with the data collection process and no writing involved.

The suggestion I have is to use a simple, reduced keyboard that has one key for each of the possible responses. Prompting could easily be done using voice synthesis with the clinician indicating his or her answer by pushing the

(continued)



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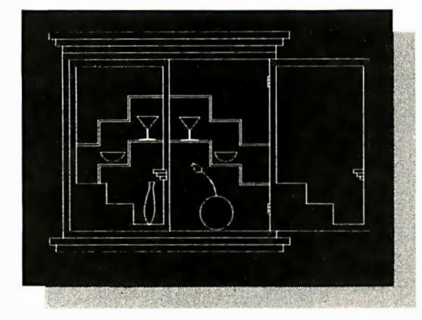
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proper key on either a wired or wireless keyboard. I demonstrated a wireless keyboard project in the July 1980 issue of BYTE.—Steve

AUDIO-AND-VIDEO MULTIPLEXER

Dear Steve,

I have attempted to build a simpler version of the system you described in your February Circuit Cellar ("Build an Audio-and-Video Multiplexer"). I wanted to use my Atari's 5-volt DC discrete-output joystick port to control the CD4066. I tried to make a simplified circuit that would allow my computer to select whether I was allowing my VCR output or the computer video output to be displayed on the TV set.

I'm not sure why I had problems, but the pictures were too snowy to use and the VCR signal would completely block out the computer video when the VCR was connected as an input. I tried to provide noise protection by using in-line capacitors grounded to the metal box for the two 5-volt control lines, the 5-volt supply line, and the ground line. I used your low-pass filter on the chip input and a matching load for the untransmitted signal to no avail. Can you help?

HARRY MALTBY
Cypress, CA

From your description, I fear that you have misunderstood what I tried to accomplish with the audio-video multiplexer.

The display you describe and the associated problems indicate that you were probably trying to use the RF channel outputs of both your computer and VCR to feed your TV set, using the CD4066 as a switch. First, the CD4066 does not have the bandwidth capabilities to pass a video or audio signal without distortion of the signal. Second, neither the CD4066 nor the multiplexer system could sufficiently isolate or switch RF without severe crosstalk and signal degradation.

Unfortunately, in this instance, the easiest solution is still the "A-B switch." You might consider controlling a coaxial relay with your computer. However, the crosstalk problem could still exist, since your TV input stage is very sensitive, and the RF feeding from your two sources is much stronger than a normal antenna signal.—Steve

SB180

Dear Steve,

I read with great interest your SB180 article (September and October 1985). It

(continued)



seems that such a unit would be ideal for my application. But before I commit to this product, it would be helpful if you could answer the following questions:

What ZCPR3 utilities and documentation are included as part of the $499 price?

What disk format does it use for the 3½-inch, 5¼-inch, and 8-inch drives? My application depends heavily on the use of all three disk sizes.

You mention optional disk format conversion programs. I am interested in the following formats:

CP/M 8-inch IBM standard
CP/M 8-inch Heath/Magnolia
MS-DOS 5¼-inch IBM PC
MS-DOS 3½-inch DG/One

Will the SB180 work with any 3½-inch drives, or do you have recommendations as to drive manufacturer or model?

Does the unit include documentation of the HD64180 chip?

Will a Z80 CP/M program run "as is" under ZCPR3 without modification?

Thanks for your help.

ALLYN ROTHMAN
Syosset, NY

I will answer your questions in the order you pose them. First, the SB180-1-20 includes the full set of ZCPR3 utilities (far too numerous to list here) plus an assembler, linker, debugger, and source for the monitor ROM, the BIOS, ZCPR3, and SB180-specific utilities. The documentation includes the book ZCPR3: The Manual, *descriptions of the utilities not covered in the book, a technical manual for the SB180 that has full setup details and schematics, and finally the HD64180 data book.*

The SB180 BIOS supports six 5¼-inch disk formats and three 8-inch formats. (The SB180 doesn't know the difference between a 3½-inch drive and a 5¼-inch drive, so the formats are the same for both sizes.) The software comes on double-sided, double-density, 40-track, "native" format disks. Other formats supported include the Kaypro 2, Osborne I, Hitachi QC-10, Ampro SS, and the standard IBM 8-inch format.

In order to use the other formats you mention, you need a utility called Uni-Form. It supports over two hundred 3½-inch, 5¼-inch, and 8-inch formats and is available from us or its authors at Micro Solutions for $69.95.

It's impossible to say that the SB180 will work with any 3½-inch drive. I have used Teac 35F drives successfully. Owners of the SB180 have reported success with other drives, but since I have only

(continued)



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The graphic display of nested command structures helps in forming good structured programming techniques. The separation of complex instructions, through proper tabbing by dANALYST, provides clarification of today's sophisticated dBASE applications. Using dANALYST you will be able to quickly check and make sure that the programs you are writing will not malfunction due to simple program errors.

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Full support is provided for multiuser Clipper™ and the network version of the WordTech™ compiler for true record and file locking. TranSec dANALYST will support multiuser operation on the following networks when used with Clipper and the Communications Horizons™ multiuser library: Novell Netware™ 4.61 or Advanced, IBM® PC Network (DOS 3.1) NetBIOS,™ Multi-Link,™ Orchid Technology,™ Alloy,™ AST,™ 3Com Ethernet.™

dANALYST also supports and can create CLP files for Clipper, LNK files for PLINK86,™ Tree Files, RSP Files for dBASE runtime support, and variable tabbing.

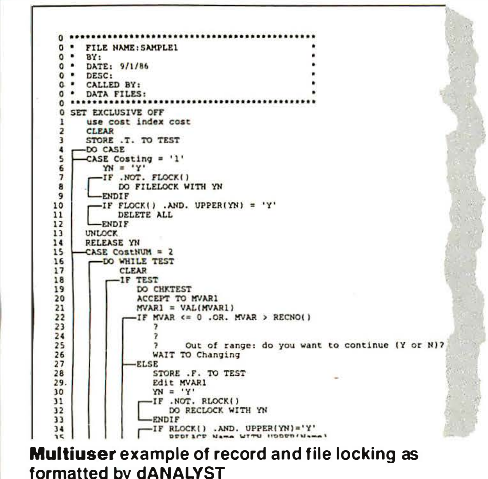
Automatic Documentation

Automatic Programmer documentation also can be added to files, along with an efficient Search Program to allow users to search for any text string occurence in the file.

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```
 0 *********************************************
 0 *   FILE NAME:SAMPLE1                       *
 0 *   BY:                                     *
 0 *   DATE: 9/1/86                            *
 0 *   DESC:                                   *
 0 *   CALLED BY:                              *
 0 *   DATA FILES:                             *
 0 *********************************************
 0 SET EXCLUSIVE OFF
 1     use cost index cost
 2     CLEAR
 3     STORE .T. TO TEST
 4   DO CASE
 5   CASE Costing = '1'
 6       YN = 'Y'
 7       IF .NOT. FLOCK()
 8           DO FILELOCK WITH YN
 9       ENDIF
10       IF FLOCK() .AND. UPPER(YN) = 'Y'
11           DELETE ALL
12       ENDIF
13     UNLOCK
14     RELEASE YN
15   CASE CostNUM = 2
16       DO WHILE TEST
17           CLEAR
18           IF TEST
19               DO CHKTEST
20               ACCEPT TO MVAR1
21               MVAR1 = VAL(MVAR1)
22               IF MVAR <= 0 .OR. MVAR > RECNO()
23                   ?
24                   ?
25                   ?     Out of range: do you want to continue (Y or N)?
26                   WAIT TO Changing
27               ELSE
28                   STORE .F. TO TEST
29.                  Edit MVAR1
30                   YN = 'Y'
31                   IF .NOT. RLOCK()
32                       DO RECLOCK WITH YN
33                   ENDIF
34                   IF RLOCK() .AND. UPPER(YN)='Y'
```

Multiuser example of record and file locking as formatted by dANALYST

```
 0 *********************************************
 0 *   FILE NAME:TEST.PRG                      *
 0 *   BY:                                     *
 0 *   DATE: 9/1/86                            *
 0 *   DESC:                                   *
 0 *   CALLED BY:                              *
 0 *   DATA FILES:                             *
 0 *********************************************
 1     use cost index cost
 2     CLEAR
 3     STORE .T. TO TEST
*** Error: LOOP statement not within DO WHILE ... ENDDO block.
 4 <==loop
 5   DO CASE
 6   CASE Costing = '1'
 7       DELETE ALL
 8   CASE Costing = '2'
 9       DO WHILE TEST
10           CLEAR
11           IF TEST
12               DO CHKTEST
13               ACCEPT TO MVAR1
14               MVAR1 = VAL(MVAR1)
15               IF MVAR <= 0 .OR. MVAR > RECNO()
16                   ?
17                   ?
18                   ? '   Out of range: do you want to continue (Y or N)?'
19                   WAIT TO Changing
20       <==<==<==<==loop
21               ELSE
22                   STORE .F. TO TEST
23                   Edit MVAR1
24                   REPLACE Name WITH UPPER(Name),;
25                   Client WITH UPPER(Client)
*** Blocking Error.
26 ?????????     else
27                   ?
28                   ?     Do you want to edit any other entrios (Y or N)?
29                   WAIT TO Changing
30 <==<==<==<==<==return
31               ENDIF
32
*** Blocking Error.
```

Debugging for the programmer is simple, fast with errors clearly visible

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TranSec Systems, Inc., 220 Congress Park Drive, Delray Beach, FL 33445

tried the Teacs, I can't make any specific recommendations.

Any CP/M 2.2 program that makes standard CP/M calls will work unmodified on the SB180.—Steve

Build Your Own Expansion Chassis

Dear Steve,

In light of the number of relatively inexpensive IBM-compatible motherboards, power supplies, and computer cases currently available, is there a way to use them to construct an expansion chassis for the IBM PC?

R. L. Cline, Jr.
Littleton, CO

The motherboards that you see advertised in a number of computer publications are just that—motherboards. A motherboard contains all the circuit traces and pads required for a working PC when populated with the proper integrated circuits. Using a motherboard is an expensive way to go when all you require are expanded control, data, and address buses.

A few years ago, when expanded function boards were not as integrated as today, expansion slots were quickly filled. In order to expand the system, you could purchase an additional box (with or without a power supply) that provided additional card slots. You would connect the expansion box to the motherboard of the host PC via cable that plugged into one of the host's card slots. With today's integration of electronics, expansion chassis are not as common as they used to be.

You can build one using an enclosure, power supply, etc., that you have seen advertised. If you use a motherboard, you will have to ensure that all components are removed, since all electrical signals will be generated by the host PC. Then it's a simple matter of connecting one of the expansion card connectors in the host PC to one in the expansion chassis on a pin-for-pin basis.—Steve ■

Over the years I have presented many different projects in BYTE. I know many of you have built them and are making use of them in many ways.

I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, P.O. Box 582, Glastonbury, CT 06033, and fill me in on your applications. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

COMPAQ advances personal



COMPAQ announces a major improvement to the industry standard, one that carries you far beyond the limits of today's "advanced technology" personal computers. It's the new COMPAQ DESKPRO 386,™ and it reaches far higher levels of speed, compatibility, performance, and expandability than have ever been attainable in personal computers. Dozens of separate

Introducing the new COMPAQ DESKPRO 386™

enhancements have been combined in one desktop computer to make the COMPAQ DESKPRO 386 the most advanced personal computer in the world. There's no personal computer more ideal for power users, networking, and connecting to a mainframe.

The most advanced personal

advanced-technology computers

The new high-speed, 32-bit, 16-MHz Intel® 80386 microprocessor forms the heart of this breakthrough. It's the latest from Intel's popular family of microprocessors that now power well over nine million industry-standard PC's. As such, it runs all the popular personal productivity software you already own two to three times faster than ever *and* now lets you do things never before possible on personal computers. But the chip is only the beginning of this story.

8088 8086 80286 80386

The Intel 80386 microprocessor is faster and much more powerful than any of its predecessors.

Each component the very best

Performance enhancements go far beyond the microprocessor, however. Every component has been optimized to take advantage of the increased speed and power of the 80386.

We offer, for instance, far greater memory than other advanced-technology personal computers. Plus more storage with faster access. Enhanced color graphics. A built-in interface for your lightpen. And even a built-in expanded memory manager that breaks the "640K barrier" of current operating systems.

We made improvements to the keyboard and the internal fixed disk drive backup, and added a host of other features, which taken together, make this the most advanced personal computer available, and the very first to offer a true minicomputer level of performance in an industry-standard desktop computer.

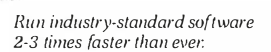
The COMPAQ Color Monitor works with software designed for a wide variety of display standards: EGA, CGA and monochrome.

The winning numbers

The new COMPAQ DESKPRO 386 features advanced 32-bit architecture that processes twice as much information as 16-bit computers in the same amount of time. Coupled with a much faster 16-MHz processing speed, it radically improves the responsiveness of spreadsheets, databases, and networks; the ease of multi-tasking; and the power of engineering software. Because the 80386 is compatible with today's software, it is setting a clear direction for the future. It preserves your investment in software and training while allowing the development of powerful business programs, far more advanced engineering software and artificial intelligence applications.

No compromises

From the integrity of its components, to its unquestionable compatibility and connectability, to its numerous enhancements, the COMPAQ DESKPRO 386 pushes all of the limits of advanced technology—with no compromises. It's clearly the computer of choice for today's *and* tomorrow's most demanding users. From the company that has the highest user satisfaction ratings in the industry.



Run industry-standard software 2-3 times faster than ever.

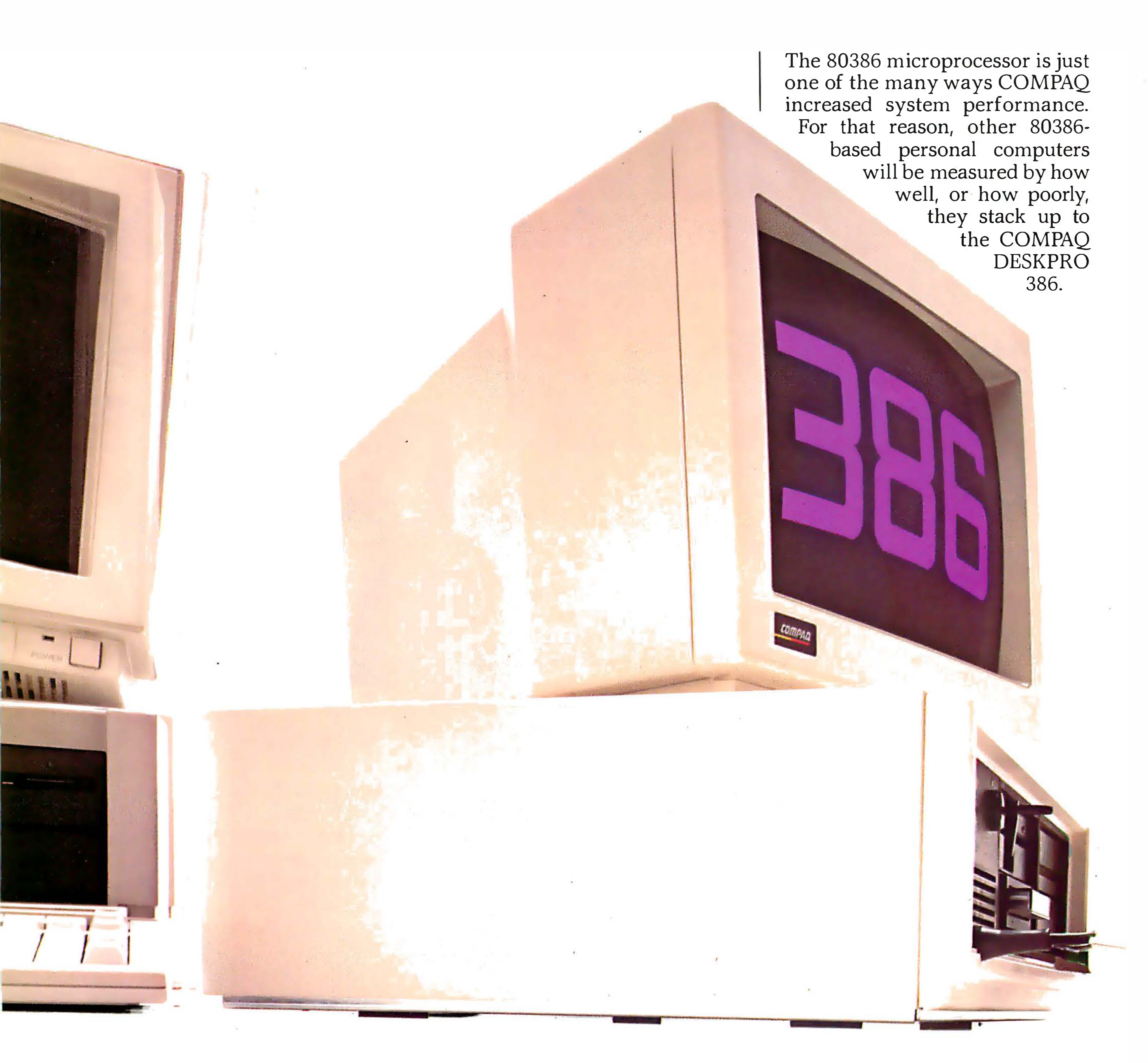
It simply works better.

computer in the world



Why the COMPAQ continue to be the world's most long after others

The 80386 microprocessor is just one of the many ways COMPAQ increased system performance. For that reason, other 80386-based personal computers will be measured by how well, or how poorly, they stack up to the COMPAQ DESKPRO 386.



The most advanced personal

DESKPRO 386 will advanced personal computer copy its engine

Greater stores of knowledge

The COMPAQ DESKPRO 386 provides the most storage capacity and performance available in any personal computer. High-performance 40- and 130-Megabyte fixed disk drives are 50 to 150 percent faster than those used in other PC's. And they store a total of 5,000 to 50,000 more pages of data.

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Storage drives access data faster, enhancing performance.

The most memorable personal computer

Break the 640-Kbyte memory barrier and use up to 8 Megabytes of high-speed 32-bit RAM with the COMPAQ Expanded Memory Manager. This software comes standard and works with programs that follow the Lotus®/Intel®/Microsoft® (LIM) Expanded Memory Specification, allowing you to build bigger spreadsheets, sort larger databases and run more programs. And unlike other personal computers, this feature requires no additional software, and the high-speed RAM uses no expansion slots, leaving more for you.

Lead a much more colorful life

When combined with the COMPAQ Enhanced Color Graphics Board, the new COMPAQ Color Monitor can display 16 colors at once from a 64-color palette. And this same board provides the high-resolution graphics—640 × 350—that many users require.



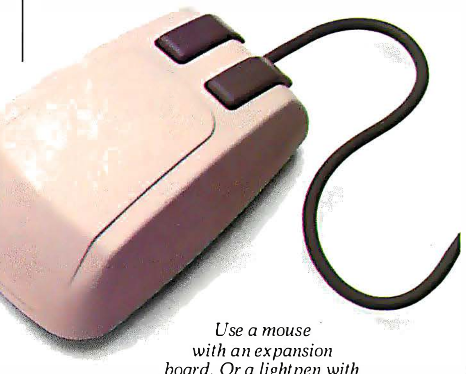
Expanding horizons

Exceptional expandability lets you add as many as four internal storage devices. You can add more RAM, too. Up to 10 Megabytes of RAM can be placed on the system board without using an expansion slot; 14 Megabytes using only two. You can also add our Enhanced Color Graphics Board that has a lightpen interface built in. This leaves four expansion slots compatible with industry-standard expansion boards. So you can communicate with mainframes, in a network, or in a multi-user environment.

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We build more into the COMPAQ DESKPRO 386, with more care. We have included interfaces for printers and modems. We protected storage devices with shock isolation systems. We improved the keyboard to help touch typists avoid mistakes and simplify common chores. And we offer a full one-year warranty.

Some companies may copy one or two features of our latest computer. But it will be years before they copy them all. That's just one more reason why COMPAQ Computers are recognized as best in their classes by industry experts and users alike.



Use a mouse with an expansion board. Or a lightpen with a built-in interface on the COMPAQ Enhanced Color Graphics Board.

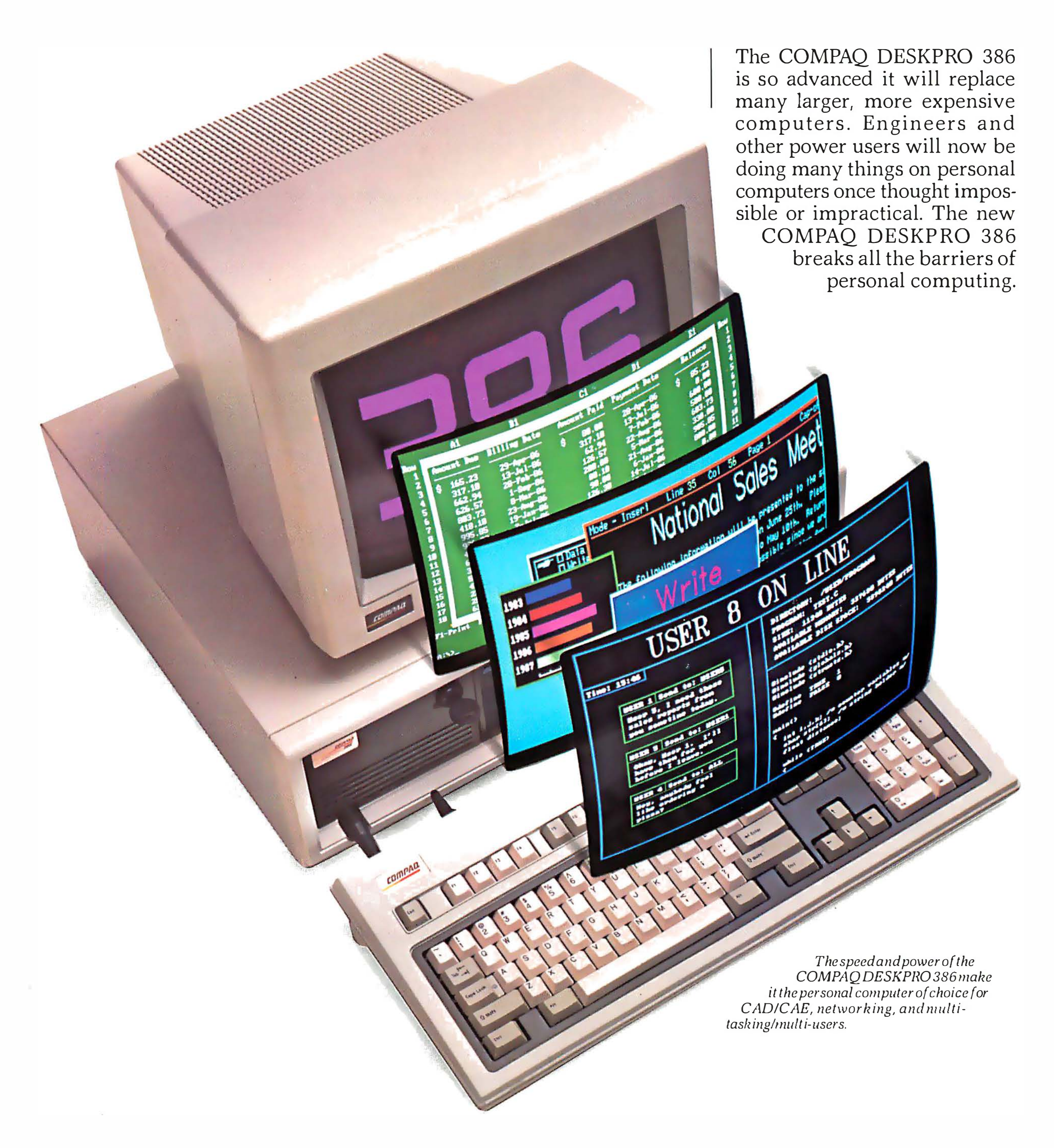
The most advanced personal computer because it incorporates the most advances.

It simply works better.

computer in the world



COMPAQ creates computer that



The COMPAQ DESKPRO 386 is so advanced it will replace many larger, more expensive computers. Engineers and other power users will now be doing many things on personal computers once thought impossible or impractical. The new COMPAQ DESKPRO 386 breaks all the barriers of personal computing.

The speed and power of the COMPAQ DESKPRO 386 make it the personal computer of choice for CAD/CAE, networking, and multi-tasking/multi-users.

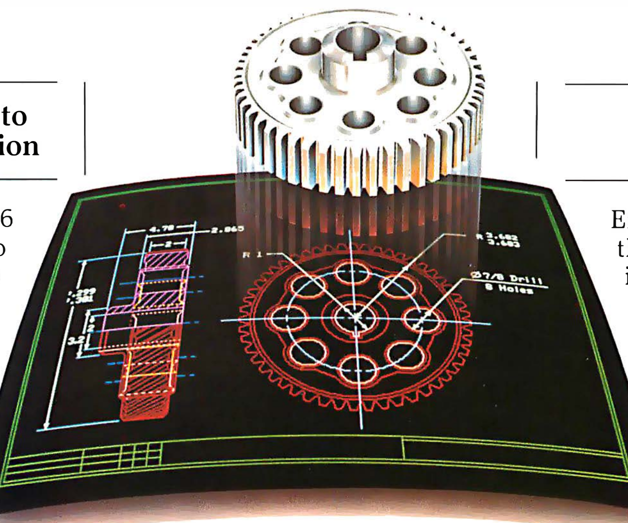
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the first personal thinks it isn't

The better alternative to the dedicated workstation

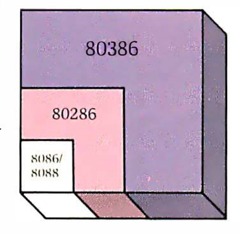
The COMPAQ DESKPRO 386 is a powerful alternative to dedicated systems that do one thing, like computer-aided design, extremely well. Now, you can match their performance, and still run hundreds of industry-standard programs as well, with a system costing thousands of dollars less.



CAD/CAE programs like AutoCAD™ enable you to do detailed electronic modeling, and the speed of the 80287 coprocessor provides real-time response.

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Faster disk drives, 32-bit architecture and a large linear address space allow software developers to easily modify minicomputer programs for use on the COMPAQ DESKPRO 386. Plus, you get minicomputer-level performance with your current personal productivity software.



The 80386 runs software written for earlier chips and adds more power.

Net gain

With the COMPAQ DESKPRO 386 as your network file server or multi-user host computer comes greater productivity. Your system will run faster than ever. And you can handle additional users with no loss of performance.

Multi-task master

Running several programs simultaneously, and switching between them, has never been better. Its speed and vast memory capacity make the COMPAQ DESKPRO 386 ideal, especially when running software under XENIX® System V/286 by COMPAQ.

Exceptional speed and memory make the COMPAQ DESKPRO 386 ideal for multi-tasking. You can run several programs at the same time and switch between them.

Building bridges to engineers

Engineers can now turn to the COMPAQ DESKPRO 386 instead of costly minicomputers or mainframes. Used with the 80287 coprocessor option, it gives you the speed you need. In addition, the new COMPAQ Color Monitor and Enhanced Color Graphics Board offer resolution required for most graphics applications with a built-in interface for those who use a lightpen.

Artificial intelligence

The speed, memory and storage of the COMPAQ DESKPRO 386 now make artificial intelligence in personal computers a real possibility. Soon available, these new AI programs promise to make personal computing even easier than it is now. The COMPAQ DESKPRO 386 is an investment in the future that pays handsome dividends today.



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computer in the world



History in the making from a company that knows how

Very few personal computer companies have managed to gain the worldwide respect and acceptance from computer users that COMPAQ has. That's because from the outset, we made clear our intentions—no compromises.

COMPAQ makes the widest line of desktop and portable business personal computers, each tops in its class, giving COMPAQ the highest user satisfaction ratings in the industry.

First *and* best

The COMPAQ DESKPRO 386 is the first PC from a major manufacturer based on the new 80386 microprocessor. Its power, speed, performance, and built-in features exceed every other personal computer you can buy. Not surprising from a company with a history of being first with the best.

A long line of firsts

COMPAQ was the first to introduce a full-function portable computer that could do more than most desktops.

We were the first to offer desktops that were faster and more expandable than the IBM*-PC.

The first to offer an internal fixed disk drive backup system.

The first to introduce a desktop more powerful than the IBM PC-AT*. And the first to offer an equally powerful, yet *portable* 80286-based personal computer.

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EXPERT SYSTEMS 85:
PROCEEDINGS
OF THE FIFTH
TECHNICAL
CONFERENCE
OF THE BRITISH
COMPUTER SOCIETY
SPECIALIST GROUP
ON EXPERT SYSTEMS
Martin Merry, ed.
Cambridge University Press
New York: 1986
334 pages, $39.50

STRUCTURE AND
INTERPRETATION OF
COMPUTER PROGRAMS
Harold Abelson
and Gerald Jay Sussman
with Julie Sussman
MIT Press
Cambridge, MA: 1985
542 pages, $34.95

SOFTWARE VALIDATION,
VERIFICATION, TESTING
AND DOCUMENTATION
(A SOURCE BOOK)
Stephen J. Andriole, ed.
Petrocelli Books
Princeton, NJ: 1986
300 pages, $49.50

**EXPERT SYSTEMS 85:
PROCEEDINGS OF THE FIFTH TECHNICAL
CONFERENCE OF THE BRITISH COMPUTER
SOCIETY SPECIALIST GROUP ON EXPERT SYSTEMS**
Reviewed by Paul E. Hoffman

Dozens of expert system products are available for microcomputers, but the concepts and the technology they represent are not the most advanced available. The articles in *Expert Systems 85* indicate that the current generation of expert system shells is only a first step in the evolution of expert systems. Apparently, current research is rapidly advancing the usefulness of expert systems.

Expert Systems 85 is a collection of 24 papers presented at the British Computer Society's expert system conclave held in December 1985 at the University of Warwick in England. The papers are strictly academic and do not propose to be related to the current family of microcomputer expert system packages. Judging from the range of these papers, it is evident that the increasing power of expert systems will continue to diversify.

OVERVIEW

The papers in *Expert Systems 85* cover many of the major topics in expert system research: the user interface, planning systems, uncertainty, and the definition of knowledge. While some focus on very small areas, others deal with large issues that also relate to areas of computer science well outside of expert systems.

The first paper is by Martin Merry, both the program committee chairman and editor of this collection of proceedings. While he theorizes on the potential of expert system research, he regards the current state of expert systems skeptically: "The well-known early expert systems, DENDRAL and MYCIN, date from the late 60s and early 70s. . . . Most current applications work involves very few substantive new ideas over these early systems."

Merry goes on to describe three topics of expert systems research: knowledge-based planning, new architectures for expert systems, and qualitative reasoning. He assesses these fields realistically, pointing out that although a great deal of theory has been described, very little of it has been

(continued)

ILLUSTRATED BY LINDA SCHARF

applied to working systems. Merry is optimistic about the future of academic expert systems research and feels that the current attention will help advance the field.

INTERNATIONAL RESEARCH

The remaining 23 papers deal with much more specific issues and are often based on the applied research projects of the authors. Some are implementation discussions of specific systems, such as a browser for a knowledge base of ecological facts, which I'll go into shortly. Others are attempts to define some of the key terms in knowledge engineering, such as those found in the paper titled "Deep Knowledge Representation Techniques."

Expert Systems 85 is interesting in that none of the papers are from Americans. In the U.S., we are accustomed to reading mostly American research papers. Many of the researchers published in *Expert Systems 85* work in the U.K., although researchers from France, Italy, Bulgaria, and Holland also have papers in this collection.

USER INTERFACE

One of the many problems that expert system designers face is taking in and displaying knowledge. For input, these problems include validation that user input can be considered factual—that an input is not a conclusion based on other facts and rules that should be used instead. To add further complications, there are many levels of knowledge. For output, an expert system must decide what the user really wants to find out and how to convert the information in the knowledge base into a form that is best suited to the user.

For example, "The ECO Browser," prepared by a group of people at the University of Edinburgh, describes the design considerations for a system that lets users browse through a knowledge base of ecological information. The program has to cope with a loosely structured knowledge base, inexperienced users, and users who don't know what they want to get out of the system when they start using it. The paper describes how the browser program achieves these goals.

"What Do Users Ask?—Some Thoughts on Diagnostic Advice" explores one of the major acknowledged weaknesses of current expert systems, namely the mismatch between the user's needs and the system's abilities. The author, who works for British Telecomm, defines the methods that human experts use to suggest remedies for any kind of problem: negotiated remedies, evaluation of a proposed remedy, and explanation of existing remedies. He goes on to describe how these different methods of arriving at a goal will affect how users interact with computer experts.

UNCERTAINTY

Many computer users marvel at the fact that knowledge bases can deal with uncertain information. MYCIN can use rules that include a relative amount of uncertainty and come up with a result that includes the degree of confidence it has in that result. However, simple values of

(continued)

uncertainty, such as "if *A* and *B* are true, then *C* is 90 percent certain to be true," are inadequate at describing the way that most humans confront probabilistic choices.

In "Inference Under Uncertainty," the authors explain some of the many problems faced by expert systems when they have to confront uncertain data. The authors point out significant areas where human experts perform significantly better than their computer counterparts. For example, most experts must cope with cases where there is inconsistent information. Human experts can take this into account on a case-by-case basis much more easily than expert systems are able to.

To overcome some of these problems, the authors of "Symbolic Uncertain Inference: A Study of Possible Modalities" formulate a mathematical notation for uncertainty in expert systems. They show that there are many types of uncertainty (such as imprecision, guesses, etc.) and that expert systems must be very careful in their handling of uncertainty. They conclude that, "Using classical expert systems techniques and logic, we hope both to have a better intelligence of inexact reasoning and to build efficient mechanisms."

APPLICATIONS

Many of the articles in *Expert Systems 85* also cover future applications of expert systems. In "An Application of Knowledge Based Techniques to VLSI Design," the authors show how expert systems can be embedded in CAD software to help designers connect parts of a VLSI chip. The decisions that go into device interconnection are based on a very large set of rules. Instead of forcing the person designing part of the VLSI to test the interconnections, an expert system can suggest connection strategies.

Other articles in this collection cover the application of expert systems to real-time process control, hardware troubleshooting, and office management. Some of the more theoretical articles point out the massive difficulties involved in implementing applied expert systems. For instance, "ESCORT: The Application of Causal Knowledge to Real-time Process Control" discusses an expert system that can control part of a chemical separation process on North Sea oil platforms. However, "Real Time Multiple-motive Expert Systems" cites many examples of conflicts that real-time expert systems will encounter when they are forced to simultaneously evaluate sensor data, formulate plans of action, and act on those plans. The paper concludes that current expert systems are not nearly flexible enough to mimic human experts.

FORECAST

Expert Systems 85 provides a very broad view of the academic research being done on expert systems. It is clear from the book that the systems in use today will be vastly improved as more effort goes into solving some of the thorny problems relating to knowledge and representation. Merry sums up the near future by saying, "We must be careful not to assume that mere publicity is sufficient to solve these problems; mounting large scale projects

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which require unsolved research questions to be answered before they can be completed is rather unwise."

Paul E. Hoffman (2000 Center St., Suite 1024, Berkeley, CA 94704) consults on artificial intelligence and edits Text in Computers, *a new scholarly journal.*

STRUCTURE AND INTERPRETATION OF COMPUTER PROGRAMS

Reviewed by Haim Kilov

Though *Structure and Interpretation of Computer Programs* by Harold Abelson and Gerald Jay Sussman with Julie Sussman is intended as a textbook for entry-level computer science at Massachusetts Institute of Technology in Cambridge, Massachusetts, it is also recommended for professional programmers who are really interested in their profession.

The book is based on the idea of abstraction, successfully used throughout to "increase the conceptual clarity." Indeed, the titles of three of the five chapters use the term "abstraction." The language used is Scheme, a modern dialect of LISP with lexical scoping. The authors show quite a lot of programming paradigms that are language-invariant. One can wholeheartedly agree with the choice of paradigms, which are not just proclaimed but actually used repeatedly. However, the authors simultaneously ignore both the use of the same paradigms in traditional imperative language programming and, more strikingly, in program correctness and related methodology issues as stated by Dijkstra, Hoare, Wirth, Gries, and others. In some cases, the authors succeed in not using the classical terminology when they present well-established paradigms. No reference is made to program correctness or to contributions in programming methodology by the authors mentioned, despite a lengthy reference list. (Note, however, that these authors also do not usually refer to the subculture presented in the book.)

Experienced programmers as well as readers with some maturity will find the presentation interesting, useful, and instructive. Although the main underlying topic of the book—the use of abstraction in controlling complexity—is convincingly shown throughout, the intended audience (entry-level students) will need to have a gifted instructor to keep pace with the chapters presented here. Most readers could benefit from rereading some parts of the book.

The authors use a case study approach, and the reader is encouraged to actually use the computer with the Scheme interpreter. Nevertheless, it is possible, though more difficult, to follow the book without access to such an interpreter. The authors show only a part of the story—the means to trace a particular execution: to test a program, to simulate its execution, or to use the interpreter in order to convince the reader of something. This is not enough because, remembering Dijkstra's remark, testing can show the presence of errors, but not their absence.

(continued)



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> ...their competition, the Panasonic machines are well made, sturdy printers that should serve well in the various applications for which they were designed. ...
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So, whether your business is big, small or in-between, you'll find a printer with features to love every bit as much as the critics. Like—as one reviewer observed—extraordinary near-letter-quality on our dot matrix models. They also come standard with impressive high-resolution graphics capability. So you can add graphs, charts, illustrations—even your company's logo.

> with this little printer.
> As far as I'm concerned, the KX-P1091 produces not near letter quality but rather true letter quality in this mode. You'd really have to strain to distinguish it from typewriter quality. ...
> the company produced fast, courteous, and knowledgeable answers.
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> **PC—SEPT. 17, 1985**

Not to be outdone, all our daisy wheel printers give you sophisticated advances like boldface, shadow and underline.

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> KX-P3151. It is a well-built product that promises to deliver many hours of trouble-free operation. The print quality is clear and well-defined. The alignment of characters on adjacent lines is also excellent, a sign of a well-designed paper and printwheel transport system.
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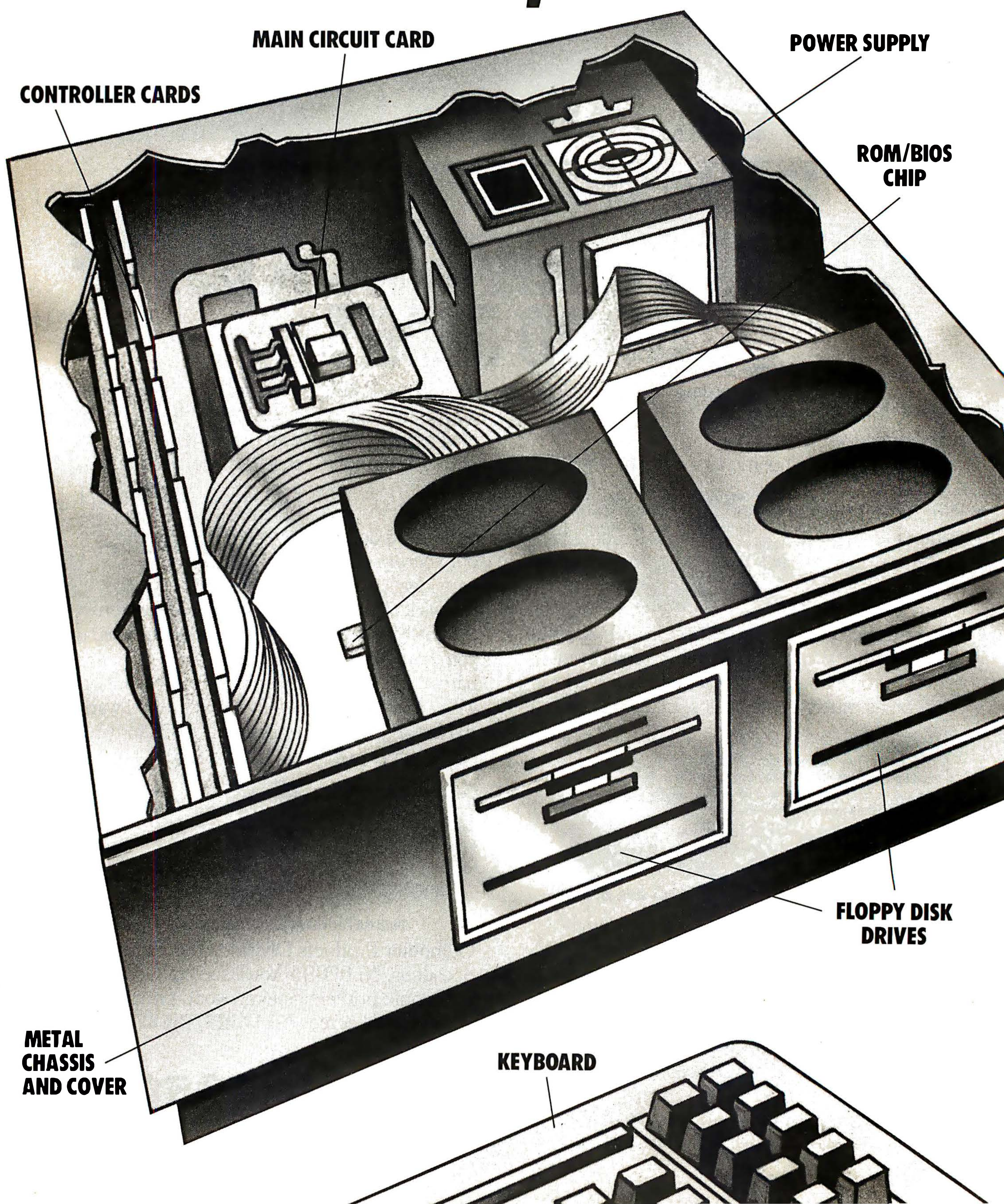
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Inquiry 245

ANYONE CAN BUILD A CLONE, BUT...



Correctness arguments are needed but are not mentioned anywhere in the text. (See "Program Transformation" by John Darlington, August 1985 BYTE.)

The range of topics covered is very wide. The book begins with "Building Abstractions with Procedures," which instills the idea of procedures as black box abstractions, and goes through "Building Abstractions with Data," which includes information hiding, data structures, and data representation—right up to top-down design of sizable programs using data-directed programming and generic operators. Then assignment is introduced, and problems dealing with local state are considered, giving rise to the notion of mutable objects. Streams and lazy evaluation are next, and the authors discuss the merits and shortcomings of functional programming.

"Metalinguistic abstraction" is covered in a chapter that establishes (and interprets) new descriptive languages developing the ideas set forth earlier. A LISP dialect evaluator is shown as well as a logic-programming-based query language and its evaluator. In the last chapter, a more traditional register machine is designed to execute the LISP evaluator (to do this a language is developed!). As an alternative, a LISP compiler is designed next for this machine. The last section shows the implementation of list-structured memory on top of "conventional" computer memory (including garbage collection). In such a manner, the authors mention diverse and important programming concepts, including not only a lot of textbook ones, but also query optimization in DBMSs, infinite loops and the meaning of "not" in logic programming, various primality tests, functional programming problems with bypassing assignment using streams, possible inadequacy of pure syntactic reasoning, and so on. Many of these are topics of active current research, and references are made to results published in the 1980s.

This enthusiastically written book is not easy reading, but neither is programming. When the authors develop solutions for nontrivial problems, they convincingly show the only right way of doing this—erecting abstraction barriers. First, abstract operations are presented without regard to implementation details, and only then is their implementation given; moreover, at times a hierarchy of such abstraction layers is used. This main idea is used time and again, and the authors' justifications of the decisions made in building abstractions are excellent, irrespective of the technical means used, which become more involved from chapter to chapter. Such presentations include elegant top-down developments of systems for symbolic differentiation, database query management, and compilation for a register machine. (Again, the use of this same principle in such imperative languages as Modula-2 or Ada is not even mentioned, as if these ideas were nonexistent there; the idea of abstract data types and encapsulation is mentioned only in passing.)

The more experienced reader will find the book instructive because of its new look at familiar concepts as well as for its many novel and interesting ones.

The authors include a lot of suitably annotated programs

(continued)

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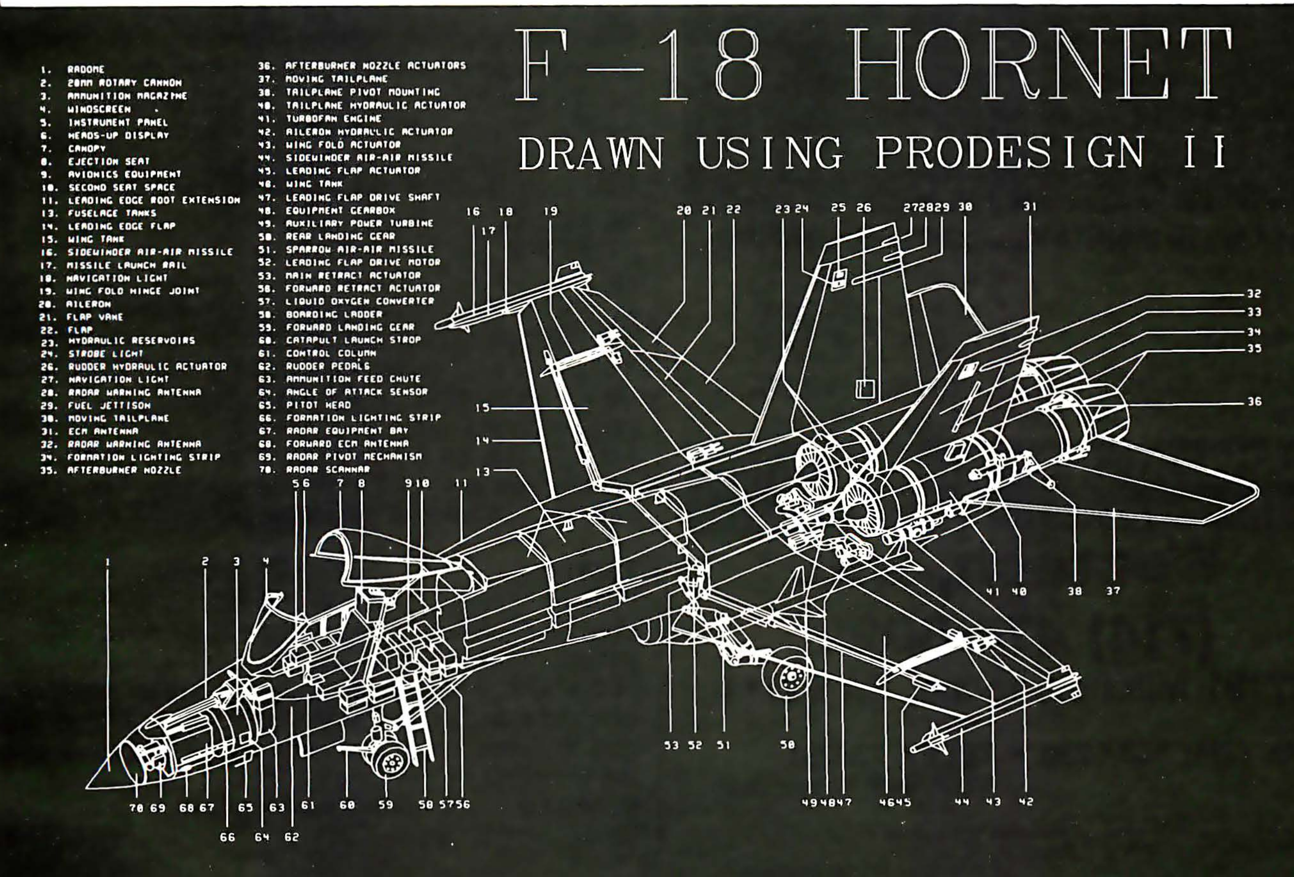
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and program fragments. Some of them are simple, others more complex. The development of the latter is shown usually in a mixture of top-down and bottom-up ("tools to construct a language of") approaches, with more emphasis on top-down, and the reader can, with some effort, understand these programs. The amount of interesting examples presented by Abelson and the Sussmans make reading and studying their book fun. All the procedures are included in a thorough index. The typographic quality of the text is unusually high; I did not notice any misprints. Ample stimulating exercises (without solutions) are an integral part of the text. The choice of the particular abstract operations and the choice of particular representation is often elegant, but how and why it was made remains at times a secret of the authors.

Despite its shortcomings, this experiment in creating an unusual, modern, and demanding first computer science text is successful.

Haim Kilov (Karl Marx St. 75-13, Riga 11, U.S.S.R.) is involved in both the design and implementation of relational database management systems and computer science education. His papers and reviews have been published in the U.S.S.R. and the U.S.

SOFTWARE VALIDATION, VERIFICATION, TESTING AND DOCUMENTATION (A SOURCE BOOK)

Reviewed by John McCormick

Software Validation, Verification, Testing and Documentation is a collection of government publications whose aim is to develop software that is easy to use and maintain. The techniques and methods described by the collection's various authors are not language- or operating-system-specific; they are well-organized general procedures that can be applied to almost any software production problem. Each report also contains its own glossary and bibliography.

"Planning for Software Validation, Verification and Testing" is edited by Patricia B. Powell of the National Bureau of Standards. An overview of the software development process and management, it contains some software maintenance considerations. Detailed examples, among them code excerpts, are included to clarify points developed in the text. This report's primary goal is to ensure not only that the finished software works but that the development team and its management can have a high level of confidence in its quality and reliability.

TESTING

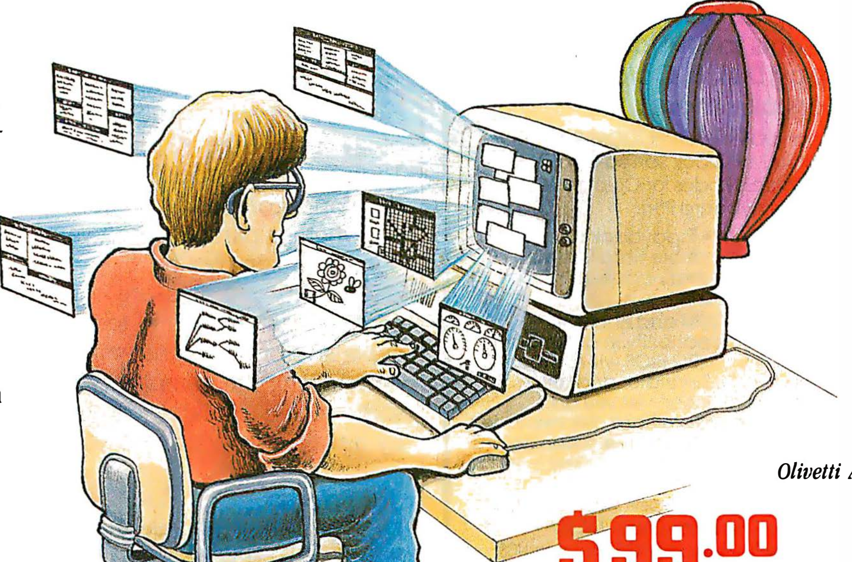
Book Two, entitled "Validation, Verification and Testing of Computer Software," covers validating software at the application level. Reliability and testability are the bywords of this book, with an emphasis on the importance of test data and especially test results. Statistical analysis of test data to determine its appropriateness is stressed, as is the technique of inserting errors statistically similar to those anticipated in the actual application. Twenty-one

(continued)

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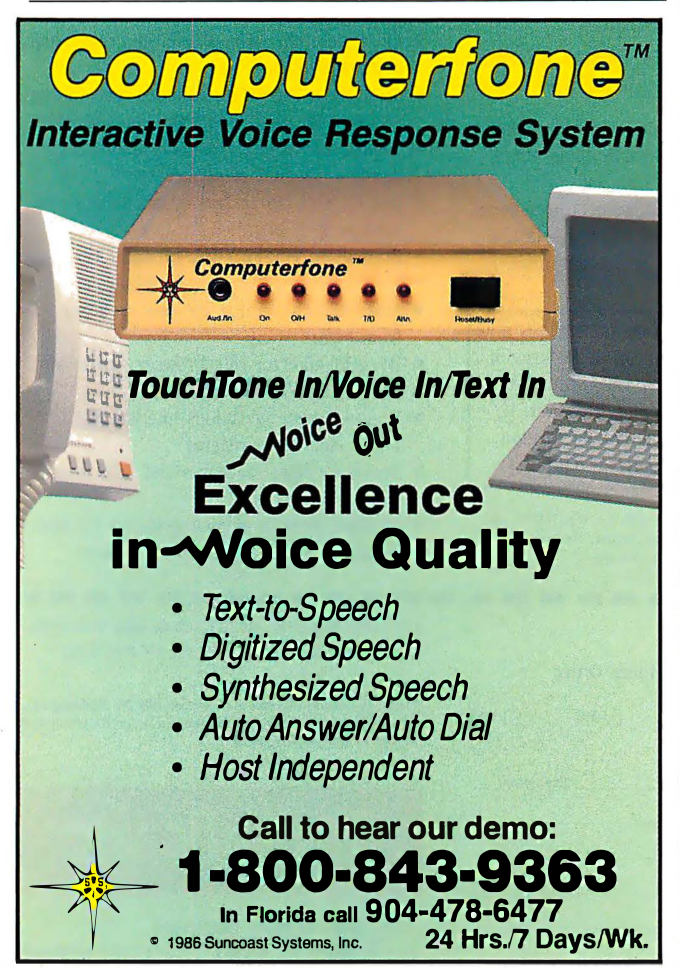
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automatic and manual testing and verification techniques, including peer review and simulation, are described.

Approach

The highly structured approach to software testing is discussed in "Structured Testing: A Software Testing Methodology Using the Cyclomatic Complexity Metric" by Thomas J. McCabe. This piece uses graph theory to develop a complexity measure that is used in determining whether particular software is inherently untestable due to its complexity.

Testability is a measure of whether the software is so complex that the task of testing it becomes unreasonably expensive or time-consuming. This section is devoted to determining the complexity and testability of particular software and ultimately determining whether the complexity must be reduced or the testing technique improved.

30 Tools

From algorithm analysis and analytic modeling of systems designs to test support facilities and walk-throughs, Book Four, entitled "Software Validation, Verification, and Testing Technique and Tool Reference Guide," describes 30 verification, validation, and testing tools.

This section on practical applied testing contains a wealth of information for someone actively seeking a tool for a specific testing purpose. This book includes specific references for each of the 30 tools.

The discussion of each tool includes a description of its basic features, the input and output information, an example, the difficulty in learning the technique, costs, and effectiveness. This information will help you quickly narrow down the search for the appropriate tool.

Management Level

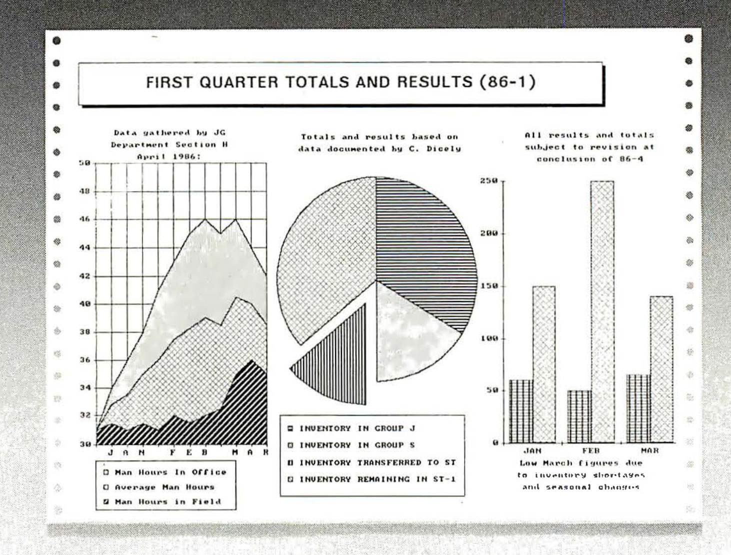
"Management Guide to Software Documentation" by Albrecht J. Neumann explores the management aspects of documentation production and includes a number of checklists intended to guide managers in the production of software documentation.

Each book in this volume begins with a short abstract and list of the section's keywords. This entire work is distilled from reports published by the U.S. Department of Commerce's National Bureau of Standards. The text is liberally sprinkled with charts, tables, graphs, and examples. Some sections deal with general managerial considerations, and others deal with specific programming applications, providing useful information for a variety of software development specialists.

This publication is for the serious professional who deals with software at the production level and not for the software user. While the book does not deal specifically with software maintenance and operation, these topics are certainly made easier with well-verified, -tested, and -documented software.

John McCormick (Box 99, RD#1, Mahaffey, PA 15757) is a freelance writer specializing in personal computers. Formerly with Wang Labs, he has also worked with IBM mainframes. ■

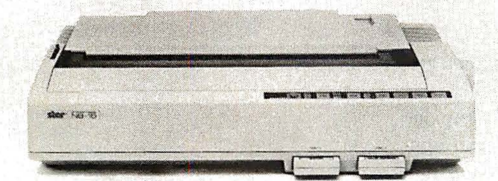
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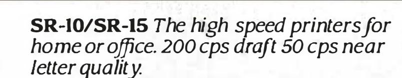


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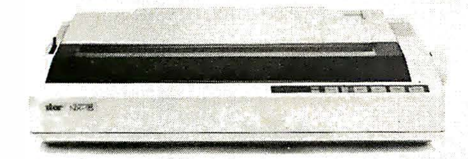


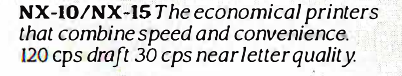
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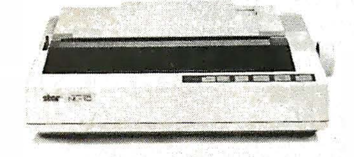
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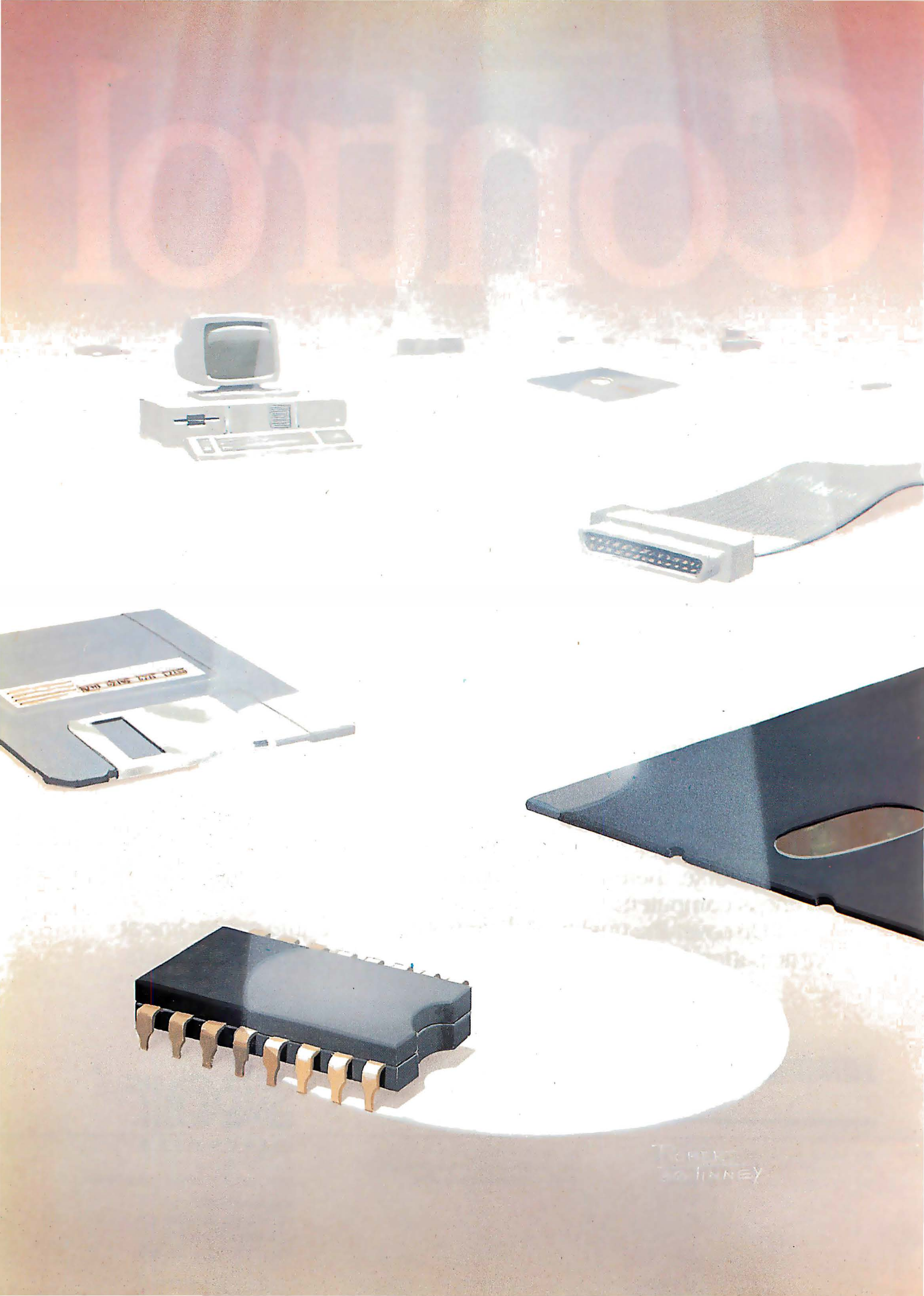
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Features

THIS MONTH'S FEATURES include two Product Previews. The first, "The Compaq Deskpro 386" by Tom Thompson and Dennis Allen, offers an advance look at Compaq's new high-performance IBM PC AT–compatible system based on Intel's 80386 microprocessor. The second, "Lotus Manuscript" by George A. Stewart, previews Lotus Development Corporation's technical word processor. Watch for complete reviews of both products in the near future.

Steve Ciarcia begins the Circuit Cellar by saying, "Graphics has more of a direct influence on user satisfaction than any other aspect of a computer." Up until now, his SB180 computer has had graphics capabilities that paled in comparison to the graphics on other popular computers. This is no longer the case. In the first part of a three-part series, Steve describes the GT180, which is both an expansion board and an intelligent graphics system. The GT180 will combine with the SB180 to provide high-quality graphics at a low cost.

We also have two Programming Insights on the agenda this month. In "Extracting the *n*th Root from a Binary Number," Lau Siu Wo explains the general algorithm he developed for extracting any real root from a binary number. In "Passing Filenames to Compiled BASIC," Bruce Hubanks walks us through an assembly language subroutine he created to retrieve the command-line text for a compiled BASIC program.

Gregg Zehr's "Memory Management Units for 68000 Architectures," this month's 68000 feature, looks at the design options that speed up memory management.

Finally, Paul Walton takes us into the Soviet Union for an inside look at the state of microelectronics. Is Russia's computer culture anywhere near as advanced as ours? The answer is a resounding "Nyet."

The Compaq Deskpro 386

A *high-performance* PC AT–*compatible system based on* Intel's 80386

Editor's note: The following is a BYTE product preview. It is not a review. We provide an advance look at this product because we feel that it is significant. A complete review will follow in a subsequent issue.

About a year ago, Intel began selling samples of its latest-generation microprocessor, the 80386 (see Microbytes, November 1985 BYTE). After much anticipation this processor has finally made its way into the design of several new microcomputer systems. Compaq, the Houston-based manufacturer widely known for its IBM-compatible computers, introduced one of the first such systems, the Compaq Deskpro 386. The new Compaq machine was designed to be compatible with 80286-based systems, such as the IBM PC AT, yet take advantage of the 80386's processing power for better performance. Like the PC AT, the Deskpro 386 was also designed to run much of the existing software written for the older 8086/8088 Intel microprocessors.

System Description

From the outside, the Deskpro 386 is Spartan in design (see photo 1). The system is housed in an IBM PC AT–style box with indicator lights, a security key, and space for up to four half-height disk drives or other storage devices. The back panel of the system unit has a 9-pin serial port and a 25-pin parallel printer port. The system comes with your choice of a standard 84-key PC keyboard or the Compaq Enhanced Keyboard, an IBM RT PC–style 101-key keyboard.

The standard configuration, called the Model 40, sells for $6499 and includes 1 megabyte of RAM, a 1.2-megabyte floppy disk drive, and a 40-megabyte hard disk. Compaq also offers a system configured with a 130-megabyte hard disk (instead of the 40-megabyte hard disk) called the Model 130, which sells for $8799.

Because no production machines were available at press time, we examined a preproduction Model 40 system with an additional megabyte of RAM (2 megabytes total), a numeric coprocessor, a 360K-byte floppy disk drive, a 40-megabyte tape cartridge unit, and a color graphics adapter. The system runs MS-DOS 3.1.

Inside the machine is a 192-watt power supply, a fan, and a single motherboard (see photo 2). The motherboard contains a real-time clock with battery backup, seven expansion slots, the CPU, and a 32-bit slot occupied by the System Memory Board. Four of the expansion slots are full-size 8-/16-bit slots and three are 8-bit slots, of which two are full size and one is half size. Compaq's multipurpose disk controller, which is included with the base system, occupies one of the full-size 8-/16-bit expansion slots. The disk controller supports two 1.2-megabyte floppy disk drives, a 40-megabyte hard disk, and either a second 40-megabyte hard disk or a 40-megabyte tape backup unit. The Model 130 requires an additional drive controller in one of the full-size 8-/16-bit expansion slots for the 130-megabyte hard disk.

Unleashing the 80386

The CPU is a version B1 80386 microprocessor running at 16 MHz. The 80386 has built-in memory management and supports a numeric coprocessor, but the motherboard has a socket for only a 4- or 8-MHz 80287—not an 80387. The 80386 uses two separate 32-bit buses for addressing and data. The processor can dynamically size its data bus to handle 32-bit or 16-bit data bus operations. Also, the address bus can be pipelined; the processor can perform address decoding for the next bus operation during the previous bus cycle, allowing for overlap of bus activity.

To tap the performance potential of the 80386, Compaq designed a high-bandwidth CPU bus and memory bus. The CPU bus is a 32-bit nonmultiplexed address and data bus that provides signals for interfacing to both the 32-bit memory bus and the 8-/16-bit expansion bus. In the event of bus contention between the memory bus and the expansion bus, the memory bus has priority. The expansion bus is electrically compatible with existing plug-in cards for the PC AT. However, we did not test any plug-in cards in the system.

The memory bus provides the bandwidth necessary to take advantage of the 80386's speed and bus pipelining. It uses a paged memory architecture to improve access times. The memory bus does not include I/O status or control signals, and it is not intended to be used as a general-purpose bus.

BY TOM THOMPSON AND DENNIS ALLEN



Photo 1: *The Compaq Deskpro 386 with optional color monitor, 40-megabyte backup unit, and extra 1.2-megabyte floppy disk drive.*

The maximum physical memory this bus can address is 16 megabytes. However, using Compaq options you can expand the system only to 10 megabytes of RAM on the 32-bit bus.

FASTER MEMORY

Naturally, a faster memory bus requires faster memory. The System Memory Board is equipped with thirty-six 256K-bit static-column RAM chips soldered directly to the board for a total of 1 megabyte of memory with 4 bits for parity. Using this arrangement with 100-nanosecond RAM reduces the number of wait states required for memory access in the paged mode to nearly 0. Memory cells within the same physical page can be accessed rapidly by keeping the row address of the RAM constant while modifying the column address. For such consecutive memory fetches within a page, access times can be as low as 50 ns. During nonpaged operations, access times are about 100 ns. A PC AT, on the other hand, is equipped with 150-ns RAM.

The System Memory Board has sockets for another megabyte of RAM chips, which costs $549. Additional memory must be added in 1-megabyte increments. When upgrading memory, you must change a set of

(continued)

Tom Thompson and Dennis Allen are BYTE *technical editors. They can be reached at* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

IN BRIEF

Compaq Deskpro 386

Company
Compaq Computer Corporation
20555 FM 149
Houston, TX 77070
(713) 370-0670

Price
Model 40: $6499
Model 130: $8799

Microprocessor
Intel 80386 16-MHz, 32-bit microprocessor

Main Memory
1 megabyte of 100-ns RAM, expandable to 14 megabytes
128K ROM containing system code

Disk Memory
1.2-megabyte 5¼-inch double-sided floppy disk drive
40-megabyte hard disk with 30-ms access time (Model 40)
130-megabyte hard disk with 25-ms access time (Model 130)

Keyboards
Detachable 84-key IBM PC keyboard plus numeric keypad and 10 function keys;
Detachable 101-key IBM RT enhanced keyboard with numeric keypad, cursor keys, and 12 function keys

Ports
9-pin serial port
25-pin parallel port

Optional Peripherals

Compaq color monitor (EGA compatible)	$799
Color adapter card	$599
Monochrome monitor (amber or green)	$255
Video display controller board	$199
40-megabyte tape backup unit	$799
8-MHz 80287 math coprocessor	$349
Deskpro 386 Technical Reference Guide	$149
Additional 1 megabyte of RAM for System Memory Board	$549
2-megabyte piggyback board with 1 megabyte of RAM	$849
2-megabyte piggyback board with 2 megabytes of RAM	$1398
8-megabyte piggyback board with 4 megabytes of RAM	$2999
Additional 4 megabytes of RAM for piggyback board	$2699

9-pin jumpers on the memory board. You can also set the jumpers to reduce the 640K-byte base memory of the system to 512K or 256K.

A special expansion board can be piggybacked on the System Memory Board to bring the total memory to 4 megabytes using 256K-bit chips. Compaq also offers a piggyback board with 4 megabytes of RAM using 1-megabit chips for $2999. This board has sockets for another 4 megabytes of RAM ($2699), again using the 1-megabit chips. Together, a fully populated System Memory Board (2 megabytes) and expansion board using 1-megabit chips (8 megabytes) give you a total of 10 megabytes of 32-bit high-speed memory. You could also use two 16-bit boards configured with 2 megabytes each to bring the Deskpro 386 to a maximum of 14 megabytes using Compaq options. In doing so, however, you would lose the speed advantage of the 32-bit memory bus.

The Virtual Machine

An important feature of the 80386 CPU is its virtual mode. Combined with memory paging, this mode allows a real mode environment (64K-byte segments, 1 megabyte of physical address space, no memory protection) to be emulated anywhere within the 80386's physical address space of 4 gigabytes. The virtual mode also features I/O protection so that the host operating system can imitate various I/O ports. Compaq claims to have successfully "virtualized" an 8086 machine in the Deskpro 386. In other words, MS-DOS programs should run on the Deskpro 386 with little or no modification. More important, ill-behaved programs—programs that read or write directly to hardware I/O ports rather than using DOS functions—should operate properly.

To access memory beyond the 640K bytes of base memory under MS-DOS control, the Deskpro 386 uses a proprietary software driver called the Compaq Extended Memory Manager (CEMM). The CEMM takes advantage of the 80386's memory paging features to emulate the Lotus/Intel/Microsoft (LIM) expanded memory specifications in the Deskpro 386's 32-bit memory system. In effect, it virtualizes an Intel AboveBoard. You can install the CEMM and define the memory size (up to the 8-megabyte LIM limit) using the MS-DOS configuration file, CONFIG.SYS. Using the CEMM with the Deskpro 386's 32-bit memory should result in favorable speeds compared to using the LIM specifications with a 16-bit memory board.

This virtual machine arrangement promises to resolve possible software compatibility problems with existing 8086/8088 and 80286 real mode programs, at least in the single-user mode. In fact, the 80386's virtual mode will allow copies of different operating systems to execute real mode applications concurrently with memory protection and privilege control. But for now at least, Compaq

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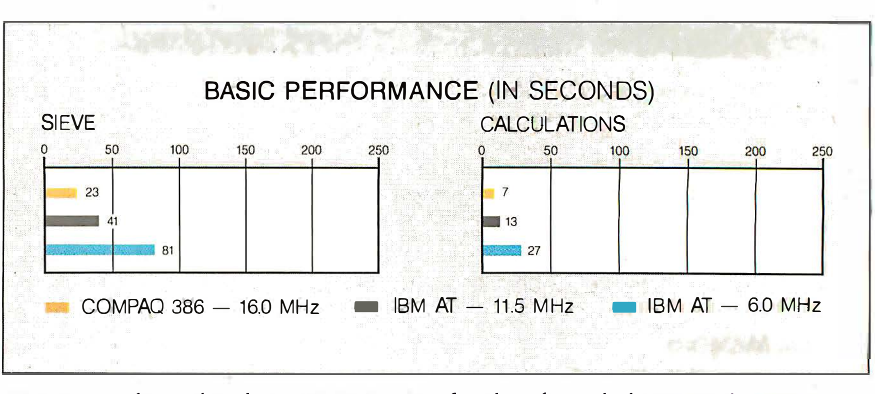


Figure 1: *The results of two* BYTE BASIC *benchmarks,* Calculations *and* Sieve, *run on the Compaq Deskpro* 386. *These times are compared with the same benchmarks run on a* 6-MHz IBM PC AT *and a* PC AT *specially equipped with* 100-*ns memory running at* 11.5 MHz.

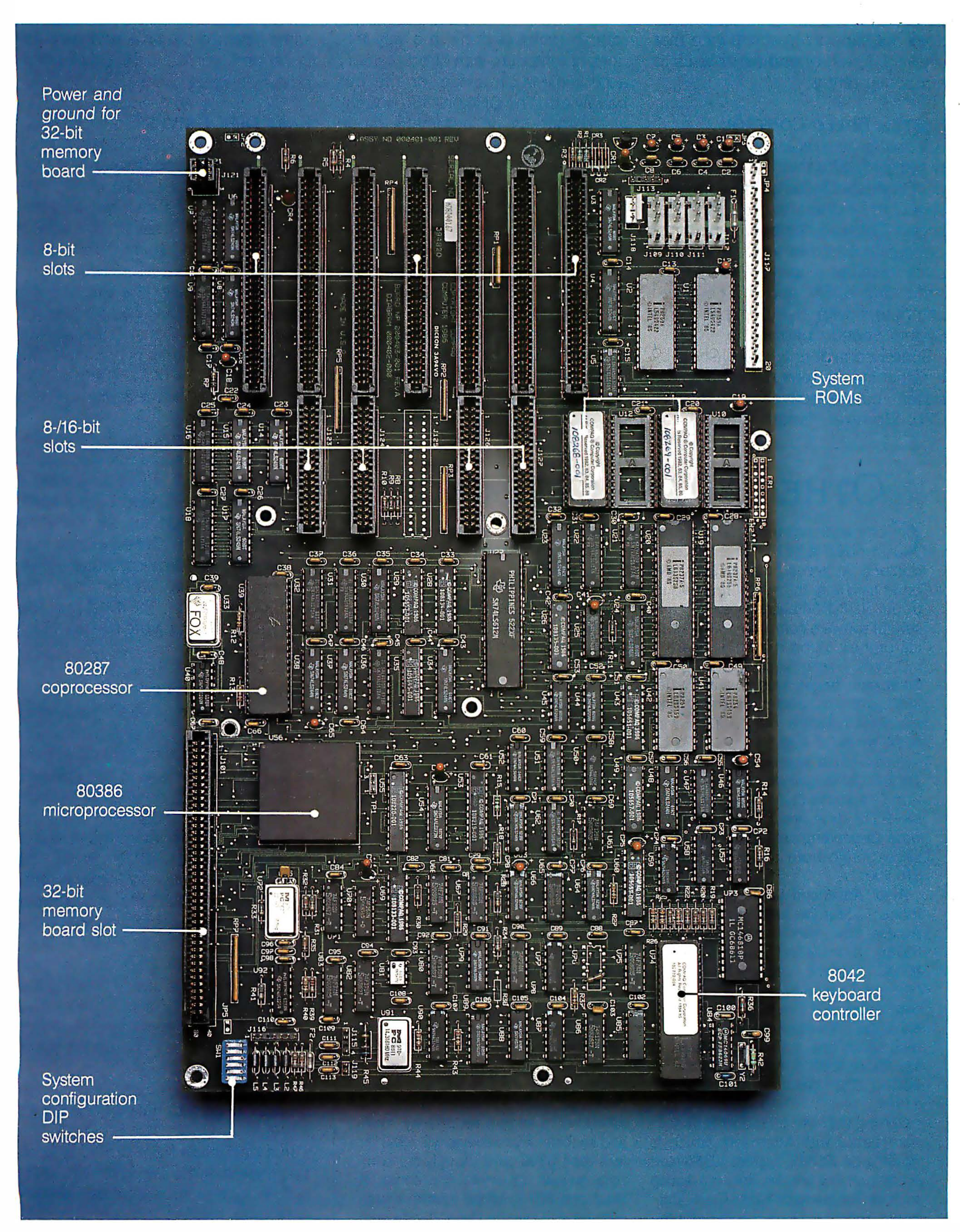


Photo 2: *The Compaq Deskpro 386 motherboard.*

does not support host software that allows different operating systems to run concurrently.

SYSTEM SPEED CONTROL

Another feature promises compatibility with programs that use time-dependent code that relies on the computer system to be operating at a particular speed. Compaq hopes to trick copy-protection schemes and certain program displays (typically games) by simulating 8088- and 80286-based computers with the Deskpro 386's System Speed Control.

Speed control is accomplished by lengthening the refresh cycles on the system bus, effectively slowing the CPU. However, lengthening of the refresh cycles is done in a way that does not interfere with direct memory access (DMA) transfers or the bus bandwidth. The Deskpro 386 normally operates in an automatic mode where the CPU speed is reduced to 8 MHz—essentially mimicking a PC AT—each time a program accesses a floppy disk drive. The system resumes its high-speed operation as soon as the disk I/O is finished. Performance is not degraded since the system must wait on the slower disk drive.

An MS-DOS command, MODE, allows you to select a system speed manually. You can select a 4-MHz 8088, a 6- or 8-MHz 80286, or a 16-MHz 80386 system speed using this command. The speed remains the same (even through a keyboard reboot) until you alter the setting or a power-on reset occurs.

FAST DISK DRIVES

To complement the Deskpro 386's data processing performance, Compaq used high-speed disk drives. The 40-megabyte hard disk has an average access time of under 30 milliseconds, and the 130-megabyte hard disk's average access time is under 25 ms. In contrast, the PC AT's 20-megabyte hard disk has an average access time of 40 ms. Data transfer rates are 5 megabits per second (the same as the PC AT's 20-megabyte hard disk) and 10 megabits per second, respectively.

For hard disk backups, the 40-megabyte tape drive has a transfer rate of 500 kilobits per second, which is about twice the speed of the drive previously offered for the Deskpro line of computers. The tape drive uses a new DC2000 tape cartridge, unlike its predecessors, which used the DC1000. However, the Deskpro 386 can read—but not write to—the older tape cartridges.

DISPLAY ADAPTERS

The system we examined was equipped with Compaq's new Enhanced Color Graphics Board ($599), which also made use of the system's virtual mode. The graphics board provides 640- by 350-pixel resolution with 16 simultaneous colors, and it is compatible with IBM's Enhanced Graphics Adapter. Although the graphics board has only an 8-bit data path, the system cleverly relocates the board's ROM to the 32-bit RAM area. As a result, Compaq claims that graphics execution speed is increased by approximately four times. (The system also relocates the contents of its 16-bit ROMs to the 32-bit RAM area for speed improvement.) Compaq offers a 13-inch RGB color monitor to go with the color board for $799.

In a departure from previous Compaq systems, the Deskpro 386 does not include a monochrome display controller. Instead, the company sells its Video Display Controller Board separately for $199. It provides the

OTHER 80386 OFFERINGS

Compaq is not the only company involved in 80386 systems development. At press time, at least two other hardware manufacturers had introduced 80386-based systems, and several software companies were working on new 32-bit system software.

Corvus Systems of Santa Clara, California, began shipping its Series 386 systems in September. The Corvus machines include a 16-MHz 80386 with 512K bytes of RAM and two 32-bit memory expansion slots, and either a 70- or 126-megabyte hard disk. The Corvus systems use a PC AT–compatible BIOS developed by Award Software. Depending on the configuration, prices range from about $13,000 to $16,500.

Also, Advanced Logic Research of Irvine, California, had announced its Access 386, which uses a 16-MHz 80386. It includes a socket for an 80387 numeric coprocessor, 512K bytes of 32-bit RAM, and a 1.2-megabyte floppy disk drive. A 30-megabyte hard disk is available as an option. Access 386 is one of the first systems to use Phoenix BIOS; many more are expected. The basic system sells for $3999.

Getting into the 80386 system software battle with Microsoft, which is working on XENIX System V/386 (see accompanying article), are companies such as Softguard of Santa Clara, California. Softguard says it is developing host software, called VM/386, that will allow you to run several virtual 8086 machines simultaneously on an 80386-based system.

According to Softguard, each virtual machine could be running a different operating system. For example, you could run Lotus 1-2-3 under MS-DOS 2.1, dBASE III under DOS 3.1, UNIX, and perhaps a proprietary operating system such as Convergent Technologies' CTOS, all at the same time. Better still, the company claims that because its software will also create virtual I/O devices, such as displays, even ill-behaved programs that bypass DOS can run in the VM/386 environment. The company also claims its software will support popular user interfaces such as Microsoft Windows and IBM's TopView (VM/386 does not add a new user interface).

If successful, VM/386 certainly represents a major innovation for personal computers, but neither the concept nor the technology to implement the system is new. The VM/386 software stems from the mainframe world and 15-year-old technology. In fact, it is modeled after IBM's VM/370 operating system. Softguard says VM/386 will incorporate many of VM/370's commands and functions to let you set priority levels and so forth. The package will retail for less than $300, and though the company would not reveal the name, at least one 80386-based system manufacturer will bundle the software with its computer.

same video control as that found in other Compaq systems and is compatible with IBM's Color Graphics Adapter. The controller board can be used with either an RGB monitor (such as Compaq's), a composite color monitor, or Compaq's Dual-Mode Monitor, a monochrome monitor that sells for $255.

COMPATIBILITY AND PERFORMANCE

The 80386 CPU is object-compatible with 8086/8088 and 80286 code. To examine how well Compaq implemented this capability, we first ran several programs that we considered thorough in their use of memory and I/O operations. The BASICA present on the machine accepted and ran the IBM PC tokenized versions of two BYTE benchmark programs (the Sieve and Calculations benchmarks) without problems. The programs conveniently provided us with a performance estimate.

The results of these preliminary benchmarks are impressive when compared to a 6-MHz PC AT (see figure 1). Generally, the Deskpro 386 ran about three to four times faster. We also compared the Deskpro 386's times to those of a PC AT specially equipped with 100-ns memory running at 11.5 MHz, and the Deskpro 386 was about twice as fast.

Next, we compiled several small C programs with Manx's Aztec C, version 3.20C, using the small memory model. We used the two floppy disk drives to compile and link the programs without any problems. Not only did these programs run flawlessly, but they also ran faster than we had ever seen before.

Then we ran two programs that are considered ill-behaved in their use of DOS, the XyWrite editor, version 3.05, with SideKick version 1.52A resident. The XyWrite editor responded correctly to the cursor and function keys, and SideKick responded properly when invoked.

Admittedly, these tests are less than comprehensive. But they do indicate a high level of software compatibility.

Unfortunately, the only operating system offered for the Deskpro 386 at press time was MS-DOS. Only a true 32-bit operating system could push the system to its limits. Compaq did say that it would offer Microsoft's XENIX System V/386 during the first half of 1987 (a developer's toolkit is available now). According to Compaq, the new XENIX will be demand-paged and allow multitasking operations. We did not, however, see even a preliminary version of the package.

FOR A SELECT FEW

There are a number of folks who might benefit from using the Deskpro 386. First, there are those who need the raw processing power to run very large spreadsheets or simulations. The linear address space provided by the 80386 combined with the Deskpro 386's processing speeds not only makes such work possible but also makes it bearable. And large, complicated programs, such as expert systems, should run with respectable performance on this machine. There are also software developers who need a high-performance machine to shorten their software development cycle. Here, fast storage devices are particularly helpful. Moreover, the system's 80386 CPU allows developers to begin writing the next generation of software. For others, the large storage capacity of the Model 130 and its claimed compatibility with networking software should make it a high-powered file server.

But like any new system, the Deskpro 386 is not without its disappointments. Although CAD and desktop publishing are likely candidates for development on the machine, with no I/O signals on the memory bus and the CPU's 32-bit bandwidth to peripherals effectively halved by the expansion bus, we don't see the Deskpro 386 as a serious threat in the high-speed graphics workstation arena. Also, the Deskpro 386 seems like overkill in the single-user mode. Certainly a multitasking 32-bit operating system would put the system to fuller use.

More powerful 32-bit peripherals and operating systems are coming for the 80386-based systems. For now, the Deskpro 386 appears to be a well-engineered bridge to a new generation of those machines. ■

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BY GEORGE A. STEWART

LOTUS MANUSCRIPT

An innovative word processor for technical writing

Editor's note: The following is a BYTE *product preview. It is not a review. We provide an advance look at this product because we feel that it is significant. A complete review will follow in a subsequent issue.*

Lotus Development Corporation's newest product is Manuscript, a word processor designed for scientists, engineers, and others who work with technical documents. Manuscript, which runs on IBM PCs and compatibles, combines the features of an outline processor, a word processor, and a sophisticated print formatter. With the program, a writer can incorporate text, formulas, graphics, and tables into a single document that can be printed in presentation quality on a laser printer or in draft quality on a dot-matrix printer.

Lotus plans to sell its word processor for $495 and expects to begin shipping in November.

This early look at Manuscript is based on interviews with Lotus programmers and managers, preliminary documentation and specifications, and use of a preliminary version.

PRODUCT PHILOSOPHY

The basic assumption of Manuscript's designers was that existing, "standard" word-processing programs for personal computers are not well suited to writing and editing technical documents. Manuscript is designed to handle the specific demands of technical word processing. Let's take a look at these requirements individually.

Document length. Many word processors require that long documents (over 100 pages) be broken up into smaller files. Other programs will accept very large files, but moving from chapter to chapter or from beginning to end can be slow and awkward. Manuscript handles documents up to 800 pages long, and moving from beginning to end takes very little time, regardless of document size.

Structure. With a standard word processor, you can type in a manuscript in outline form, but the word-processing software is oblivious to the structure. Thus, adding a section in the middle of a document means that you must renumber manually all following sections on the same logical level. Manuscript renumbers sections automatically.

Format. Setting the format of a long technical document can be tedious and inefficient with a standard word processor. Suppose you want to start a new right-hand page at the beginning of every level-2 subheading, or you want to set every level-2 subheading in 14-point bold italic type. Standard word processors have no way of referring to structural entities within the document; instead, you must locate the specific level-2 subheadings and insert the necessary formatting codes. Manuscript lets you define format templates that individually govern the first five structural levels within a document.

Graphic images and tables. Standard word processors have limited facilities (or none at all) for including this type of data in a document. Usually you have to paste in the graphic or table after the document is printed. Manuscript lets you incorporate graphic images into the document at print time (graphics are not shown on the screen during editing).

Tables. Typing in tables is especially tedious with standard word processors. Revising them is even more so. Manuscript has a table editor that vastly simplifies the process.

Mathematical formulas. Producing

(continued)

George A. Stewart is a BYTE *technical editor. He can be reached at* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

formulas and equations with most word processors is a matter of compromise and approximation. A better alternative is to have them typeset, but this is expensive. Manuscript includes a command language for specifying equations precisely and uniformly. The results obtained on a laser printer are quite acceptable for mass printing quality in many applications.

Print quality. The advent of laser printers has made it feasible to produce documentation in-house without typesetting, but not many word processors are able to take full advantage of laser printer technologies. Manuscript's print formatter comes with drivers for the Apple LaserWriter and other laser printers and PostScript devices, so you can take full advantage of the various typefaces and styles available on a given printer.

STRUCTURED DOCUMENT FEATURES

Manuscript works on two kinds of documents: structured and unstructured. The latter is simply a sequential file of text—a standard word-processing document. In contrast, structured documents are made up of several entities: text, columns, blocks, and sections. Figure 1 shows the elements of a structured document.

Document structure enables you to manipulate text in new ways. You can, for instance, contract or expand the text to any level of detail, automatically number the sections, sort all the sections within a "parent" section, and insert a section and have all "sibling" sections renumbered automatically.

Text is the lowest-level entity in Manuscript. Each character of text can have its own attributes (normal, italic, bold, underlined, subscript, superscript, strike-through, and "printer-dependent"). The next higher level is the *column*, which refers to parallel sets of text that are at the same level in the outline. A *block* con-

(continued)

3 Community Issues

3.1 Neighborhood Support

The development of the park must be responsive to the needs of the neighbors as well as the city at large. Meetings will be held to ascertain the feelings of the community and to respond to these needs. Safety and security on the site as well as traffic, noise, lighting, and visual impact will all need to be addressed in public meetings.

3.2 Park Security

Police and fire department access to the site, fencing, and area lighting all will be investigated in the promotion of park security. Both the city and the neighbors will have input on this important topic so that all parties feel their concerns have been considered. Any pathways will accommodate police and maintenance vehicles. Special fencing to protect private property may be required in places.

3.3 Parking and Traffic

Parking requirements will depend on the access routes, park user type, and the method of transportation that park users choose. A thorough study involving communication with city and neighborhood groups will be completed before determination of the amount of parking. The Preliminary Traffic Survey results appear in the graph. These findings will be reviewed following the established community guidelines prior to final determination.

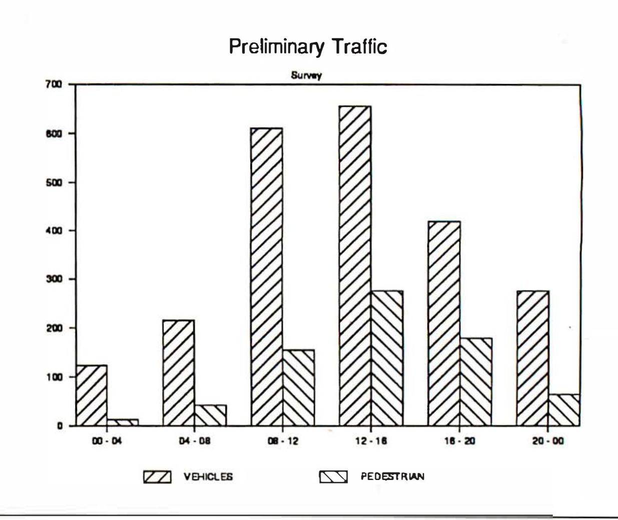


Figure 1: *Elements of a structured document: numbered section headings, text blocks, columns, and a graphic image.*

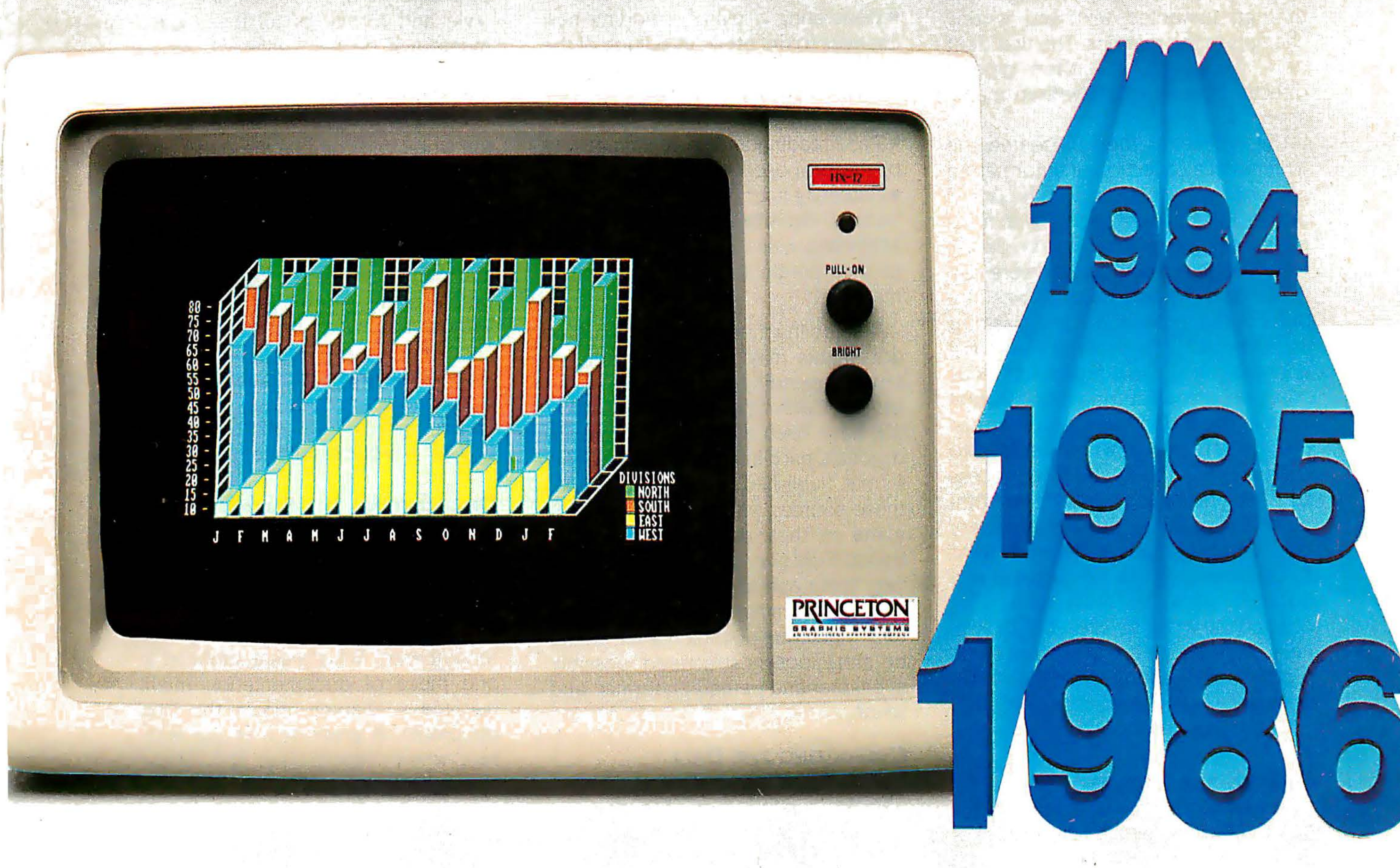
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sists of one or more columns of text at the same logical level. The next level up is the section. *Sections* correspond to the document's outline in that each section has a number that describes its hierarchical position within the document.

Manuscript assigns arabic decimal numbering to keep track of document structure. However, you can specify a variety of other numbering systems to use when the document is displayed or printed: uppercase and lowercase roman numerals and letters can all be specified in any combination to apply to the successive section levels within a document. User-definable tags are also available for the first five levels. For instance, the same section could be headed by any of the following:

Section 1.2.1
Part 1, Subpart 2, Paragraph a
Chapter I, Verse ii, Line 1

You can also choose to omit section numbering entirely from a document when it is printed or displayed.

Structured documents are much easier to peruse than unstructured ones. If the section headings are carefully chosen, a document becomes self-indexing. With a single keystroke combination (Alt plus a number), you can set the level of detail shown on the screen, enabling you to locate a particular section quickly, regardless

A Day in the Life of a Technical Writer

BY CHARLES WESTON

Once upon a time (and not too long ago), technical writers wrote manuscripts in longhand with a pencil. They edited by striking a line through unwanted text and writing changes in the margins. The first draft of a document was often typeset directly from this handwritten manuscript.

The typesetter then presented the writer with a collection of unformatted galleys to correct (again, with his or her pencil). Figures were sketched on notepads and given to an artist to be drawn. After the galleys and figures were corrected and the second draft was output by the typesetter, the pasteup cycles began. This process continued until the product was finally complete.

In one manufacturing organization back in these dark ages, an enterprising young technical writer decided to change the old tried-and-true process by typing his manuscripts into a computer and printing out a preliminary copy of his document before it went to be typeset. When his manager discovered what he was doing, he ordered the writer to "Stop this foolishness. After all, we are *writers*, not clerk-typists." The young writer and his manager soon parted company.

The young writer of the story is me.

Toward the Future

Let's look at the technical writer of today and see how a technical word processor can improve on the old method.

The writer's schedule for a typical day might include the following:

- Meeting with project engineers to discuss the format of the manual for an upcoming project. Taking notes for the theory-of-operation section.
- Incorporating these notes with notes taken last month.
- Generating a plan for adding new changes to the previous edition of the technical manual for product X and revising tables and figures to include new information.
- Proofreading and correcting galleys of the proposed manual.
- Gathering information collected from various departments (Field Service, Marketing, Sales, Quality Control, etc.) to incorporate in the new technical manual.

Assembling these notes and parts of documents may take six months or more, depending on the scope of the project. Each type of communication will have been written by various individuals, each in a particular style and format. Published documentation from these sources will be in formats germane to their departments. For instance, Field Service material would be very terse and in the technical style, possibly in military document structure. Marketing documentation would be more loosely structured, possibly in chapter and paragraph format, and so on.

Organizing the Data

The technical writer must attempt to organize this collection of information into some kind of structured outline. He or she will then use the outline to generate chapter headings and subtopics for the proposed technical manual. Later, these subtopics will be fleshed out to become the final manual.

Some of this information will be edited to produce different documents, such as a user's guide, a sales brochure, or possibly a product data sheet. The style and format of all these documents will be very different, so the writer must generate unique outlines for each of them.

With a technical document processor the writer can compile these pieces of information randomly in a single file, in distinct, individual levels. The writer can then rearrange these levels to produce a structured outline of headings and subheadings. The writer can reorganize the information repeatedly without adding or deleting anything. Figures and tables are defined at this stage of the organizing process. Before word processing, this first step in the creation process sometimes required half of a project's allotted time.

Determining the Format

In the process of combining fragmented pieces of documentation, a lot of time is spent reformatting to achieve some kind of consistency in the proposed document. Chapters need to be renumbered. What was a subhead in one piece of documentation might become a chapter title in the final document. A great deal of the technical writer's time is taken up by these mundane tasks.

A technical document processor can reformat these pieces of documentation on the fly as they are incorporated into the overall framework. A document processor with this capability makes the job of restructuring a document much easier. By using a filter, or "template," that changes the format of

of the size of the document. After moving the cursor to the section heading, you can expand the document again.

You can move sections, blocks, or columns almost instantaneously with Manuscript—regardless of the amount of text being moved. Manuscript's programmers say this is because the document isn't kept sequentially in memory. Instead, the blocks are scattered around and connected by pointers in linked lists. Moving a structural entity simply requires adjusting pointers in memory, rather than copying the actual text to a new area and deleting the original.

Manuscript provides a number of simple tools for working on the document's structure. Splitting and appending sections, subsections, blocks, and columns are all one- or two-step operations. Columns can be moved around within a block, blocks can be moved around within a section, and sections can be moved throughout a document.

Other types of text-move operations, such as moving a block, column, or table to another section, require a cut-and-paste procedure.

documents as they arrive at your word processor, all you have to do to produce the final document is locate these component parts in their respective places.

MERGING TEXT AND GRAPHICS

The technical writer must integrate tables and figures into the new document in a cohesive fashion. Often, figures and tables have to be resized a number of times until the intended page layout is satisfactory. Just about the time that a figure or table is sized to the intended page and finalized, someone will add another column or another entry that requires yet another resizing.

This doesn't sound like a monumental problem until you realize that the whole document must be reformatted to accommodate the change of space required for the revised table. Tables must be laid out separately and then pasted into the final layout. This iterative process represents most of the production time used in a documentation project.

A technical document processor enables the writer to create, size, and edit tables easily, eliminating tedious, repetitious manual labor.

HANDLING REVISIONS

Finally the document is ready in preliminary form and is sent to the various contributors for approval. It is subsequently returned with a number of changes, some of which are substantive. (Due to a design change in the product, for example, an entire new section might be required in one chapter.)

Under the old system, these revisions would have taken a great deal of time because they necessitated reformatting the entire document. The technical writer had to insert the required changes in the original manuscript and make copies for the next review cycle. He or she would have had to include a copy of the original manuscript so that reviewers could compare the revised manuscript, paragraph by paragraph, with the original manuscript.

The technical document processor combines both the new and the old manuscripts in such a way as to indicate only those words and sentences that differ between the two documents. The recently added text is underlined, and text that has been deleted is indicated by a line struck through it. As a result the reviewer has only a single revised document to read, and all the changes are immediately obvious.

The final task of the technical writer is to produce a table of contents, a list of tables and figures, and an index. The technical document processor produces these items automatically and updates them as changes continue throughout the writing process. The last step is to select fonts and type sizes for the final output of the document. When this step is complete, the technical document processor outputs the document, complete with tables, figures, and graphics, in camera-ready form.

Charles Weston is a BYTE *technical editor and former technical writer. He can be reached at* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

TABLES

Manuscript includes a table editor that vastly simplifies the task of entering, revising, and formatting tables. And since columns are one of the structural elements of the system, they can be manipulated in a variety of ways. They can be moved around; for instance, the second and third column of a table can be interchanged. Their widths can be changed, and the attributes of text (bold, italic, etc.) within a column can be changed. A particularly nice feature of tables is the variable-width column, which always expands to the right or left margin; this makes documents look neater when they are printed but doesn't require that you know what the margins will be when you construct the table.

The table editor also lets you specify the borders to be used (single or double lines) and allows individual control of the line type for interior and exterior column borders.

Once a table is set up, entering data into it is very easy. You can enter all of the information that belongs in a given cell (row-column intersection) and then move to another cell in the same row or column and continue entering the text. Manuscript adjusts all the table rows and borders to accommodate cells of different sizes.

MATHEMATICAL EQUATIONS

Manuscript has a command language for specifying mathematical formulas and equations. When output to a printer, the equations appear in proper form. For instance, the command

```
\ equation "x=[−b+−root[b super
  2−4ac]]over[2a]" \
```

produces the quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

(See figure 2 for other examples.)

(continued)

The formula specification language allows you to use uppercase and lowercase Greek letters and a comprehensive set of mathematical symbols. Eight distinct bracket types are available; they are automatically sized to fit the expressions they enclose. Manuscript automatically puts variable names (Greek or alphabetic) in italic type, leaving other formula text in roman, or standard, type. The sublanguage includes a method for specifying matrix layouts and for stacking equations.

FOOTNOTES, INDEX, AND TABLE OF CONTENTS

Manuscript can generate an index, table of contents, table of figures, table of tables, and footnotes without your having to keep track of section and page numbers manually or having to number footnotes manually. Footnotes and cross-references are indicated on the display by a special marker character. A keystroke expands the marker to let you see and edit the footnote or reference.

WORD-PROCESSING FEATURES

Manuscript offers an ample selection of word-processing tools. Single- and double-keystroke commands control cursor movement by character, word, line, and screen, as well as by the structural elements of columns, sections, and the beginning and ending of the document. Single-keystroke commands are also available for deleting the individual structural elements of a document. Deleting or copying sentences or arbitrary sequences of text requires that you select the delete or copy function, highlight the text, and press Return.

The editor offers both insert and overstrike mode for entering text. Global search and replace operations offer a few extra features, such as the ability to search for a phrase with a certain attribute. For instance, you can search for all instances of **Note**: when the word is set for boldface and change them to *Notice*: in italic. It is not possible, however, to search for all words that are in boldface; you must specify a character string in addition to any attribute. Wild-card searches are not available in Manuscript.

Manuscript does not allow control characters to exist in documents, with the exception of carriage returns and tabs. You *can* search for these two control characters.

USER INTERFACE

Manuscript's user interface presents a good compromise between the

(continued)

Step Two, Curve Fitting

Curve-fitting templates are available for 1-2-3, but below a procedure for a second order least squares regression is given.

Second Order Curve Fitting

In a second order estimate the data is fitted to an equation of the form $Y(X_i) = AX_i^2 + BX_i + C$. In this case if we let X_i be each data sample and Y_i be the actual temperature for that sample, the best fit will be obtained when:

$$\Sigma(Y_i - Y^*(X_i))^2$$

is minimized. To solve for A, B, and C requires a knowledge of differential calculus. The results are:

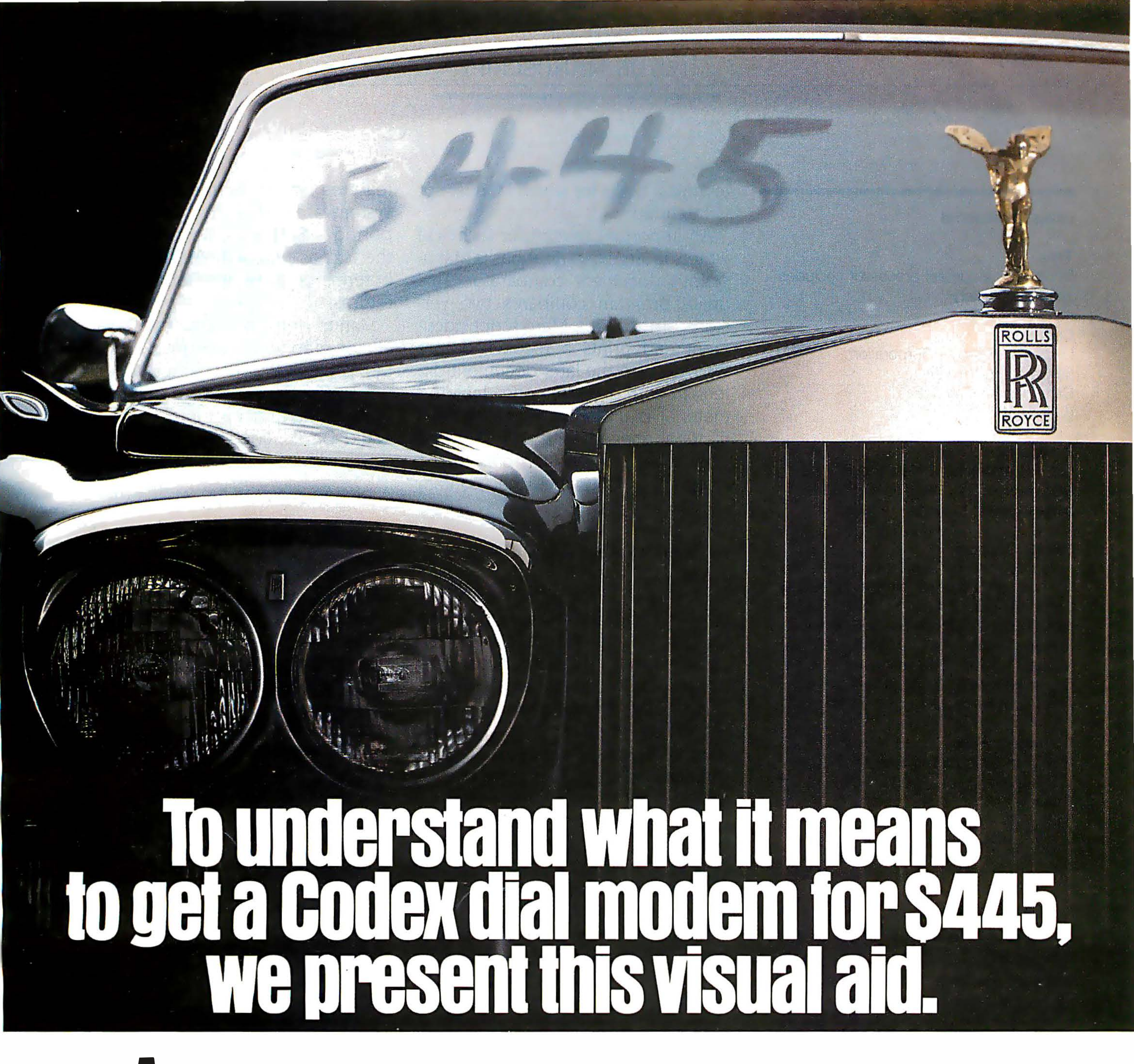
$$Y^*(X_i) = AX_i^2 + BX_i + C$$

where: **A = 0.00528 B = -1.05 C = 164.7**

Partial Sample Data Table and Regression Values

Data	Actual	Data	Actual	Data	Actual
18	179	26	147	34	132
20	163	28	142	36	129
22	157	30	138	38	126
24	152	32	135	40	123

Figure 2: *Equations and tables in Manuscript.*



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Lotus Manuscript

Type
Structured document processor (includes spelling checker)

Company
Lotus Development Corporation
55 Cambridge Parkway
Cambridge, MA 02142
(617) 577-8500

Computer
IBM PC and compatibles; requires MS-DOS version 2.0 or higher and 512K bytes of RAM; hard disk required

Printer Support
Apple LaserWriter; Hewlett-Packard ThinkJet and LaserJet (all font cartridges); Epson LQ-1500, FX-80/100, FX-85, FX-286; IBM Proprinter, Quietwriter, and Graphics Printer; Okidata ML92, ML93, ML193, and ML293; Toshiba 1300 series and P351; Diablo 630; NEC 3550; other PostScript printers; other printers to be announced

Documentation
Reference manual and tutorial

Price
$495

needs of expert users and the needs of novices. You can specify most operations by moving the cursor through a series of menus or by one or more keystrokes. When you have to input a variable parameter, the program offers a pop-up data-entry menu showing the various options available for that field. An experienced user can simply type in the needed parameter without stopping to look at the options.

A context-sensitive help facility makes it possible to use Manuscript without relying on printed reference materials. Pressing the F1 key calls up a help screen appropriate to the current operation.

UTILITIES

Manuscript includes an 80,000-word spelling checker from Proximity Software. The same package is integrated into Lotus Symphony. The spelling checker lets you create and maintain your own auxiliary dictionary, which would be essential in many of the technical fields for which Manuscript is intended.

An important feature for technical writers in large organizations is Manuscript's document comparator. This utility program compares two versions of the same Manuscript document and prints a reconciled text showing how the later document differs from the earlier one. Inserted material is underlined, and deleted material appears with a "strike out" line through it. Revision bars in the margin highlight lines that contain changes.

IMPORTING AND EXPORTING DATA

Switching to a new word-processing program might be impractical if none of your existing text files could be ported over to the new system.

Manuscript can read any ASCII-encoded text file; however, control characters other than tabs, carriage returns, and linefeeds may cause problems and should probably be removed before the file is imported. For instance, printer control codes should not be included in a text file to be imported by Manuscript. Extended ASCII characters (codes greater than 127) should also be removed.

Initially, Manuscript puts the imported ASCII text into a structured or unstructured document (your choice). In the former case paragraphs become separate blocks. In the latter case, you must break up the blocks manually. In both cases, you must define your own section boundaries between the blocks.

Manuscript can import two other forms of text files: DCA and ThinkTank. DCA (document content architecture) is an IBM structured-document standard used in a number of systems; these documents retain their structure and can be revised when imported into Manuscript. ThinkTank is a popular outliner and was one of the early models for Manuscript. (The product's code name was SOL, an apparent acronym for scientific outliner.)

Manuscript also lets you export documents in ASCII and DCA formats. Exported DCA documents retain their structure when read in by DCA-conforming programs, but Manuscript features not supported by the DCA system are lost in the process. Exported ASCII documents resemble the text as it appears on the screen in terms of indentation and carriage returns.

Manuscript can incorporate a variety of graphic images into a document: Lotus PIC, PostScript (for output to PostScript devices only), and bit-map files. For example, a pie chart could be included in a Manuscript document with the command

\ picture piechart.pic width=rm \

The width=rm parameter forces the graphic to be scaled so that it extends out to the right margin. Other scaling and sizing tools are available.

The files must contain the proper header information, so not every graphic file is automatically loadable. Some processing or conversion might be necessary.

Lastly, Manuscript can accept spreadsheet data in the Lotus 1-2-3 or Symphony format. Such data can be converted into a true Manuscript table structure or input as a simpler table in which tab characters separate the columns.

OUTPUT QUALITY

Manuscript outputs at highest quality and performance to devices equipped with a PostScript interpreter, such as Apple's LaserWriter. Based on the formatting specified in a document, Manuscript prepares the necessary PostScript commands for generating both text and graphics.

Outputting to non-PostScript devices is done through a set of custom drivers, one for each device. For text output, the drivers operate the printers in text mode, that is, using the printers' built-in character sets. Graphics mode is used only to generate special characters in formulas and for graphic images and table borders.

The advantage of this system is speed and quality of output; printing in text mode is much faster than printing in graphics (bit-image) mode. A printer's built-in character set is typically better designed than a bit-image character set can afford to be

(continued)



The C for Microcomputers

PC-DOS, MS-DOS, CP/M-86, Macintosh, Amiga, Apple II, CP/M-80, Radio Shack, Commodore, XENIX, ROM, and Cross Development systems

MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

Manx Aztec C86

"A compiler that has many strengths . . . quite valuable for serious work"

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler	Symbolic Debugger
AS86 Macro Assembler	LN86 Overlay Linker
80186/80286 Support	Librarian
8087/80287 Sensing Lib	Profiler
Extensive UNIX Library	DOS, Screen, & Graphics Lib
Large Memory Model	Intel Object Option
Z (vi) Source Editor -c	CP/M-86 Library -c
ROM Support Package -c	INTEL HEX Utility -c
Library Source Code -c	Mixed memory models -c
MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

Aztec C86-c Commercial System	**$499**
Aztec C86-d Developer's System	**$299**
Aztec C86-p Personal System	**$199**
Aztec C86-a Apprentice System	**$49**

All systems are upgradable by paying the difference in price plus $10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

C-tree $395	**Greenleaf $185**
PHACT $250	**PC-lint $98**
***HALO* $250**	**Amber Windows $59**
PRE-C $395	**Windows for C $195**
WindScreen $149	**FirsTime $295**
SunScreen $99	**C Util Lib $185**
PANEL $295	**Plink-86 $395**

MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

Manx Aztec C68k

"Library handling is very flexible . . . documentation is excellent . . . the shell a pleasure to work in . . . blows away the competition for pure compile speed . . . an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

Optimized C	Creates Clickable Applications
Macro Assembler	Mouse Enhanced SHELL
Overlay Linker	Easy Access to Mac Toolbox
Resource Compiler	UNIX Library Functions
Debuggers	Terminal Emulator (Source)
Librarian	Clear Detailed Documentation
Source Editor	C-Stuff Library
MacRam Disk -c	UniTools (vi,make,diff,grep) -c
Library Source -c	One Year of Updates -c

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

Aztec C68k-c Commercial System	**$499**
Aztec C68d-d Developer's System	**$299**
Aztec C68k-p Personal System	**$199**
C-tree database (source)	**$399**
AMIGA, CP/M-68k, 68k UNIX	**call**

Apple II, Commodore, 65xx, 65C02 ROM

Manx Aztec C65

"The AZTEC C system is one of the finest software packages I have seen"

NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3, and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

Aztec C65-c ProDOS & DOS 3.3	**$399**
Aztec C65-d Apple DOS 3.3	**$199**
Aztec C65-p Apple Personal system	**$99**
Aztec C65-a for learning C	**$49**
Aztec C65-c/128 C64, C128, CP/M	**$399**

Distribution of Manx Aztec C

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

Manx Cross Development Systems

Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST. Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and educational applications.

HOSTS: VAX UNIX ($3000), PDP-11 UNIX ($2000), MS-DOS ($750), CP/M ($750), MACINTOSH ($750), CP/M-68k ($750), XENIX ($750).

TARGETS: MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x86 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

The first TARGET is included in the price of the HOST system. Additional TARGETS are $300 to $500 (non VAX) or $1000 (VAX).

Call Manx for information on cross development to the 68000, 65816, Amiga, C128, CP/M-68K, VRTX, and others.

CP/M, Radio Shack, 8080/8085/Z80 ROM

Manx Aztec CII

"I've had a lot of experience with different C compilers, but the Aztec C80 Compiler and Professional Development System is the best I've seen."

80-Micro, December, 1984, John B. Harrell III

Aztec C II-c (CP/M & ROM)	**$349**
Aztec C II-d (CP/M)	**$199**
C-tree database (source)	**$399**
Aztec C80-c (TRS-80 3 & 4)	**$299**
Aztec C80-d (TRS-80 3 & 4)	**$199**

How To Become an Aztec C User

To become an Aztec C user call 1-800-221-0440 or call 1-800-832-9273 (800-TEC WARE). In NJ or outside the USA call 201-530-7997. Orders can also be telexed to 4995812.

Payment can be by check, COD, American Express, VISA, Master Card, or Net 30 to qualified customers.

Orders can also be mailed to Manx Software Systems, Box 55, Shrewsbury, NJ 07701.

How To Get More Information

To get more information on Manx Aztec C and related products, call 1-800-221-0440, or 201-530-7997, or write to Manx Software Systems.

30 Day Guarantee

Any Manx Aztec C development system can be returned within 30 days for a refund if it fails to meet your needs. The only restrictions are that the original purchase must be directly from Manx, shipped within the USA, and the package must be in resalable condition. Returned items must be received by Manx within 30 days. A small restocking fee may be required.

Discounts

There are special discounts available to professors, students, and consultants. A discount is also available on a "trade in" basis for users of competing systems. Call for information.

Inquiry 196



To order or for information call:

800-221-0440

without using up a great deal of memory.

The disadvantage of this system is that documents can't be printed out in the same manner on all devices. For instance, a document being prepared for a PostScript device may have specifications for large headings in four different typefaces (Times Roman, Courier, Helvetica, and Symbol). Before that document is printed on an Epson FX-80, the specifications must be changed to accommodate the limited type sizes and faces available with that printer.

When you start Manuscript, a setup menu lets you specify the printer you will use. The choice you make determines what typefaces Manuscript will offer you. Manuscript allows up 10 different faces, though few printers will actually make that many available.

To print a document using a device other than the one originally specified, you simply change the typeface map using a global typography menu or let Manuscript make the conversion.

Requirements

Manuscript runs on MS-DOS versions 2.0 and higher. It requires at least 512K bytes of RAM and a hard disk. (If you have very large documents, you probably need a hard disk anyway just for document storage.)

The program uses standard BIOS functions for keyboard input, and thus Lotus programmers say it should be compatible with memory-resident programs like SideKick and Spotlight (a product Lotus acquired when the company purchased Software Arts).

Manuscript supports the use of an extended memory board, enabling you to use memory in excess of 640K bytes. A document spooling scheme allows extended memory, RAM disk, hard disk storage, and even floppy disk storage to be treated as RAM for handling very large files.

The system provides specific support for various display cards, including IBM's monochrome, color graphics, and enhanced color graphics boards and the Hercules Graphics Card and the new Hercules Graphics Card Plus. The latter card makes it possible to display the following text attributes on the screen: normal, bold, underlined, italic, superscript, subscript, and strike-through. If the system you are using can't display all these attributes, a field on the display's status bar shows the attributes of the text at the current cursor location.

Figure 3: *Manuscript's preview option displays text and graphics as they will appear on the page, at various levels of magnification (graphics card required).*

Manuscript will support use of a wide variety of popular laser, ink jet, and dot-matrix printers (see the At a Glance box on page 98).

Manuscript Output vs. Typesetting

A Manuscript document printed on a LaserWriter cannot literally duplicate the quality of a typesetter. For one thing, the 300-dot-per-inch resolution of laser printers does not match the quality obtained when using a 1200-dot-per-inch typesetter.

It's true that Manuscript could be used to drive a PostScript-equipped typesetting machine, but the end result would still not duplicate what you would expect from a professional typesetter. Manuscript is unable to provide all the typesetting subtleties like kerning and loose and tight lines. When Manuscript underlines a word, the underline goes right through any descenders that appear on the line, contrary to typographic aesthetics.

These kinds of problems can be worked out through PostScript commands; unfortunately, Manuscript doesn't let the user enter PostScript commands directly. On the positive side, Manuscript does give you access to all of a printer's characters, some of them through the use of special backslash sequences. In this manner, one can obtain em dashes, en dashes, minus signs, opening and closing quotes, and ligatures (combined letters such as ﬂ, ﬀ, and ﬁ).

Partial WYSIWYG

Manuscript is not a true "what you see is what you get" editor. Because it supports varying point sizes and typefaces dependent on your printer and because it allows you to incorporate graphics into documents, providing a WYSIWYG system would entail operating the screen in graphics mode. Lotus designers chose to restrict the editor to the text mode (no graphics) during editing for one simple reason: speed. Tasks like scrolling and redrawing take far longer in graphics mode than in text mode.

The editor does let you see some of the attributes of the finished product: indentation, the appearance of columns and tables, and the presence

of section tags and numbers, for example. The attributes and elements you do not see on-screen are natural page and line breaks, graphics, font sizes, line spacing, and formulas.

Manuscript includes a page preview utility that lets you see the document on-screen in graphics mode before it is printed. The utility scales the output so that one page fits on the screen. A magnification window gives you a close-up of any part of the page. Text, graphics, tables, and formulas appear in these page previews. This function is available only on systems with a graphics card (see figure 3).

In the area of word processing, there's room for improvement. The pop-up windows often block the portion of the text you are working on, making it difficult to complete the dialogue required by the pop-up menu. For instance, when you want to make a global replacement, you might need to glance back at the text to see how a word is spelled or what its attributes are. You can't see the word because the menu is covering it up.

The word-processing interface is not consistent throughout Manuscript. For instance, when you're editing a document, Control-arrow advances to the next word. But when you're entering text to a menu field, Control-arrow has no effect.

I wish Manuscript had more flexibility in the area of global searches. For example, it would be handy if you could search for all carriage returns and insert a block or section divider wherever one was found. This would simplify the process of converting an unstructured document to a structured one (the automatic conversion of paragraphs to blocks during file importation is a step in the right direction).

Keyboard macros would also be a nice feature, although Lotus says you can use keyboard enhancer programs with Manuscript if your system has sufficient memory.

SUGGESTIONS FOR TESTING MANUSCRIPT

I tested a preliminary form of Manuscript. Thus it is not fair or meaningful to record any benchmark results here. However, by the time you read this, the first release of the product should be out.

Lotus believes it is creating a new product niche with Manuscript: PC-level technical/professional word processing. No doubt other companies will follow with new products for this field (or new features for old products). The text box on this page gives a checklist to help you evaluate word processors.

TECHNICAL WORD PROCESSOR CHECKLIST

- ☐ Does the system let you integrate text and graphics into the hard copy?
- ☐ Does it offer a way to specify mathematical and scientific formulas?
- ☐ What is the limit on document size?
- ☐ Does the product let you use extended memory?
- ☐ Does it recognize hierarchical document structure? How many levels?
- ☐ Does it let you see an on-screen facsimile of the document, or does it have a preview facility?
- ☐ What types of files can it import and export?
- ☐ Does it allow you to sort sections based on their headings?
- ☐ How fast does the word processor print a document? Try a document that includes a graphic image, all table, and mathematical formula. Compare the speed on a laser printer and a dot-matrix printer.
- ☐ How fast does it load and convert an ASCII text file?
- ☐ How fast can you go from the beginning to the end of a very large document (several hundred pages)?
- ☐ Does the system allow you to set up templates defining the formats for the various structural levels within a document?

PERSONAL REACTIONS

After a week's experience using a preliminary version of Manuscript, I am enthusiastic about its potential for writers. It encourages a rapid, free-flowing style of writing and lets you put down your thoughts as they occur to you, without worrying whether the sequence is ideal from an organizational standpoint. Later, you can move the ideas around to fill an outline.

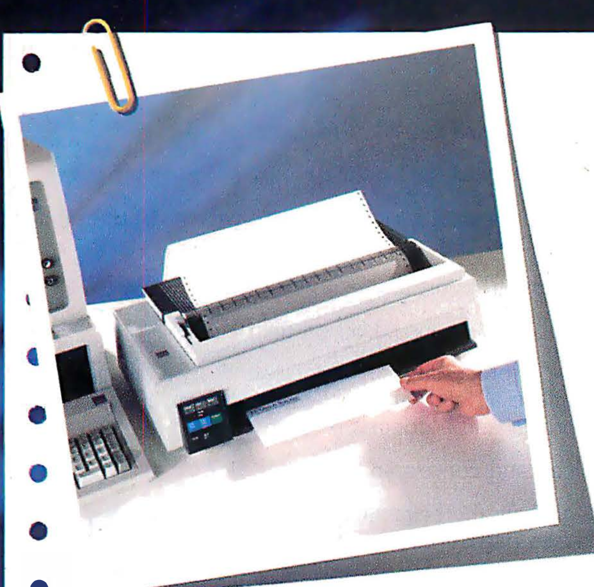
Manuscript is also a good tool for people with writer's block, because it encourages you to start writing, if only by producing a rough outline of what you intend to write. By successively refining the outline, you may discover that what seemed to be a formidable task has been transformed into a series of manageable short topics.

The product's strongest points are its structure cognizance, its ability to integrate text and graphics in a printed document, its support for PostScript devices, and its convenient user interface. On the basis of standard word-processing features, it is acceptable but not revolutionary. Presumably, Manuscript will be used by people who work with computers a lot—at least for word processing. These kinds of users tend not to mind a little product complexity if it gives them more control and convenience.

Many people will probably consider it a fault that Manuscript does not provide a "what you see is what you get" interface. And for shorter documents where speed of access is not so important, a WYSIWYG system might indeed be preferable. But for writers who must assemble large volumes of information from various sources and fit it all together into an organized whole, the decision to favor speed of operation over on-screen graphics will almost certainly be welcome. ■

Quite incredible.

The IBM Proprinter XL. Under $800.



For under $800, the Proprinter XL packs an incredible number of features into a single machine.

It's the wide carriage model of the Proprinter and it attaches to most personal computers.

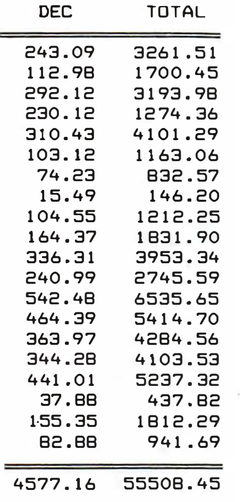
The Proprinter XL lets you print spreadsheets (see below) on paper up to 16½ inches wide. It lets you print on standard computer paper, too. And, without removing the computer paper, you can easily feed envelopes or single sheets through a separate slot in the front. You can also switch between fast-draft and near-letter-quality print modes with the touch of a button (what you're reading now was printed on a Proprinter XL). You can even do graphics. But the best thing is, you can do all this--and more--for less than $800.

J.V. ALLEN & SON, INC. YEARLY SALES (THOUSANDS)

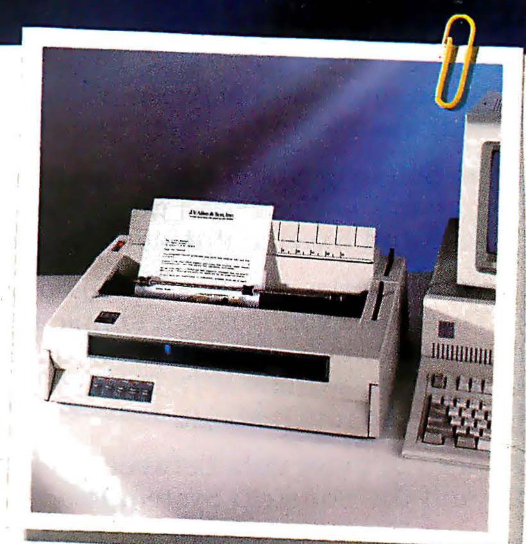
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Region 1	243.33	253.21	255.45	261.34	273.22	280.12	282.34	284.98	291.43	293.55	299.4
Region 2	132.34	135.34	137.45	140.43	141.67	146.78	142.34	146.33	149.02	151.43	164.3
Region 3	223.32	234.56	254.12	255.11	267.23	270.23	274.32	276.75	279.65	282.12	284.4
Region 4	12.34	21.43	23.45	24.98	25.32	30.98	145.98	156.90	178.89	210.21	213.7
Region 5	332.12	343.56	345.76	347.87	349.65	354.33	355.23	357.89	361.12	332.12	311.2
Region 6	89.34	91.23	93.46	94.56	95.45	96.67	97.59	98.31	99.89	101.45	101.9
Region 7	99.36	100.54	101.45	101.90	102.23	102.09	102.89	103.23	104.21	104.33	104.9
Region 8	65.34	66.37	66.98	67.12	67.36	68.23	69.41	70.12	70.78	72.65	73.9
Region 9	13.43	15.36	14.98	16.11	16.78	17.32	18.32	18.54	18.99	19.45	20.3
Region 10	96.45	97.32	98.49	99.31	100.11	101.23	101.98	102.32	102.87	103.21	104.4
Region 11	143.67	144.32	146.47	148.73	149.34	151.23	152.53	153.22	155.78	159.65	162.5
Region 12	325.43	326.46	326.98	354.32	312.29	315.46	320.21	332.87	332.91	335.12	334.9
Region 13	243.78	245.11	211.36	201.98	213.48	224.31	223.47	229.31	231.35	239.43	241.0
Region 14	540.11	540.78	541.43	543.95	544.21	544.99	545.37	543.79	548.73	549.39	550.4
Region 15	436.49	433.82	435.99	448.93	451.78	452.23	453.78	455.39	456.31	462.45	463.1
Region 16	357.36	352.57	353.11	353.98	354.32	355.52	356.26	357.41	358.32	359.29	362.4
Region 17	392.43	393.41	311.84	316.93	325.38	332.34	334.29	335.28	335.99	338.72	342.6
Region 18	431.21	433.93	434.25	435.26	435.87	436.31	436.25	437.42	437.97	438.32	439.5
Region 19	35.86	35.21	35.98	36.31	36.11	36.84	35.98	36.73	36.82	36.89	37.2
Region 20	146.73	146.99	147.36	147.93	148.91	149.32	152.52	153.19	154.21	154.79	154.9
TOTAL	6358.19	4411.52	4336.36	4397.05	4261.80	4467.34	4448.54	4496.79	4551.03	4589.78	4612.8

Incredibly quie

The IBM Quietwriter® Printer Model 2.



DEC	TOTAL
243.09	3261.51
112.98	1700.45
292.12	3193.98
230.12	1274.36
310.43	4101.29
103.12	1163.06
74.23	832.57
15.49	146.20
104.55	1212.25
164.37	1831.90
336.31	3953.34
240.99	2745.59
542.48	6535.65
464.39	5414.70
363.97	4284.56
344.28	4103.53
441.01	5237.32
37.88	437.82
155.35	1812.29
82.88	941.69
4577.16	55508.45



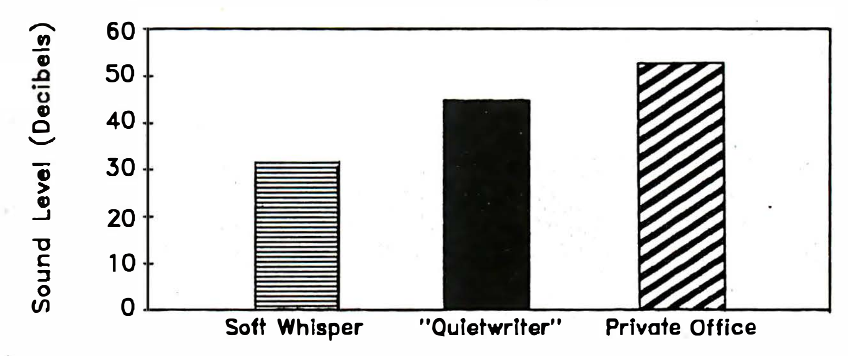
The "Quietwriter" Printer Model 2 prints as crisply as a top-of-the-line IBM typewriter (what you're reading now was done by a Model 2).

Even so, it prints so quietly you may have to remind yourself it's on.

The Model 2, which attaches to most personal computers, is terrific for creating first-rate presentations and reports.

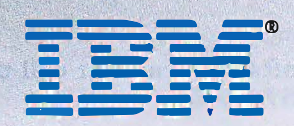
With the right software, it lets you merge text and graphics. It lets you print on single sheets, company letterhead, or even on transparencies to use on overhead projectors. And there's an optional paper feeder to help you print multi-page reports with ease.

But the best thing is, you can do all this--and more--at just above a whisper.



For free literature on our growing family of remarkable personal printers --or for the authorized IBM dealer nearest you-- call 1 800 IBM-2468, Ext. CP/104.

Or contact your IBM marketing representative.



Personal Printers.
The Finishing Touch.

Inquiry 156

BUILD THE GT180 COLOR GRAPHICS BOARD

PART 1: BASIC TECHNOLOGY

BY STEVE CIARCIA

Achieve PGA *resolution on the* SB180 *at a fraction of the cost*



Graphics has more of a direct influence on user satisfaction than any other aspect of a computer. For the most part, CP/M and ZCPR3 users have been excluded from a club whose ranks are swelled by owners of IBM PCs, Ataris, and Apples. With the GT180, I will endeavor to rectify this inequity and present a high-performance graphics subsystem for the SB180 that surpasses the graphics capabilities of most presently available computers at significantly less cost. Borland International has helped supply utilities that provide the basis for advanced graphics software development.

The GT180 (graphics technology for the SB180) is both an expansion board and an intelligent graphics system. As a plug-in peripheral to the SB180 XBUS, it adds Professional Graphics Adapter (PGA)-type 640- by 480-pixel color graphics capability to the SB180. When mated with the SB180, the two-board set defines a low-cost SCSI/RS-232C ported graphics terminal for any computer system (see photo 1).

Those who use the GT180 as a general-purpose workstation have the ability to add modern graphics while retaining compatibility with existing Z-System and CP/M application software. The GT180 can also serve as an embedded graphics engine for stand-alone applications like a graphics/videotext terminal, a presentation graphics system, or image processing. Finally, the graphics subsystem design core can easily be ported for application in non-SB180 systems like IBM PC, VME, Multibus, and S-100. In this case, the GT180 serves as a low-cost development tool for prototyping and bootstrapping the ported design.

GT180 OVERVIEW

The GT180 graphics specifications are compared to those of the IBM PGA and Enhanced Graphics Adapter (EGA), the Macintosh, Commodore's Amiga, and the Atari 520ST in table 1.

The key to the design is a recently announced CMOS VLSI graphics processor, the Hitachi HD63484 ACRTC (advanced CRT controller), and two companion chips: GMIC (graphic memory interface controller) and GVAC (graphic video attributes controller). These are supplemented by a highly integrated CMOS Brooktree BT450 palette D/A converter; a 512K-byte frame buffer that can hold three screens of data as well

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached at P.O. Box 582, Glastonbury, CT 06033.

Table 1: *The GT180's graphics specifications are compared with those of other popular microcomputers.*

	GT180 (TTL)	GT180 (Analog)	Apple Macintosh	Atari 520ST	Commodore Amiga	IBM CGA	IBM EGA	IBM PGA
Resolution	640×400	640×480	512×350	640×200*	640×400	640×200†	640×350	640×480
Colors	16	16/4096	1	16/64	16/4096	2	16/64	256/4096
Digital/Analog	digital	analog	digital	digital	analog	digital	digital	analog
Scan Mode	noninterlaced	noninterlaced	noninterlaced	noninterlaced	interlaced	noninterlaced	noninterlaced	noninterlaced
Graphics Coprocessor	yes	yes	no	no	yes	no	no	yes

*Atari 520ST is 320×200 with 16 colors or 640×200 with 4 colors or 640×400 monochrome.
†IBM CGA is 640×200 with 2 colors or 320×200 with 4 colors or 160×100 with 16 colors.

as a library of graphics objects like windows, fonts, or icons; and an IBM PC-compatible keyboard connector (see figure 1).

The GT180 display resolution is 640 by 480 pixels with 16 of 4096 colors. It can also be set to 640 by 400, 640 by 350, 640 by 200, 320 by 200, and other resolutions by changing the initialization parameters (the lower resolutions also require changing the crystal frequency). The GT180 has both TTL RGBI (red-green-blue-intensity) and analog RGB outputs and can directly connect to a number of standard CRT monitors, for example, the Princeton Graphics SR-12 and SR-12P (see photo 2).

The GT180 is a big project that can't be easily explained in a few pages. As with any sophisticated computer peripheral these days, the end product is a combination of hardware and software. So that you can recognize the dividing line between these two camps and understand why I have built the GT180 as I have, I will begin with a description of basic graphics technology. This will also help those who may need a refresher course.

The GT180 project is spread over three months. Part 1 is devoted to the basic technology and understanding the hardware/software dividing line of a graphics peripheral. Part 2 presents the hardware and details the individual VLSI components. Part 3 gives an explanation of the GT180 Graphix Toolbox written by Borland International and also demonstrates its application using Borland's CP/M-compatible Modula-2.

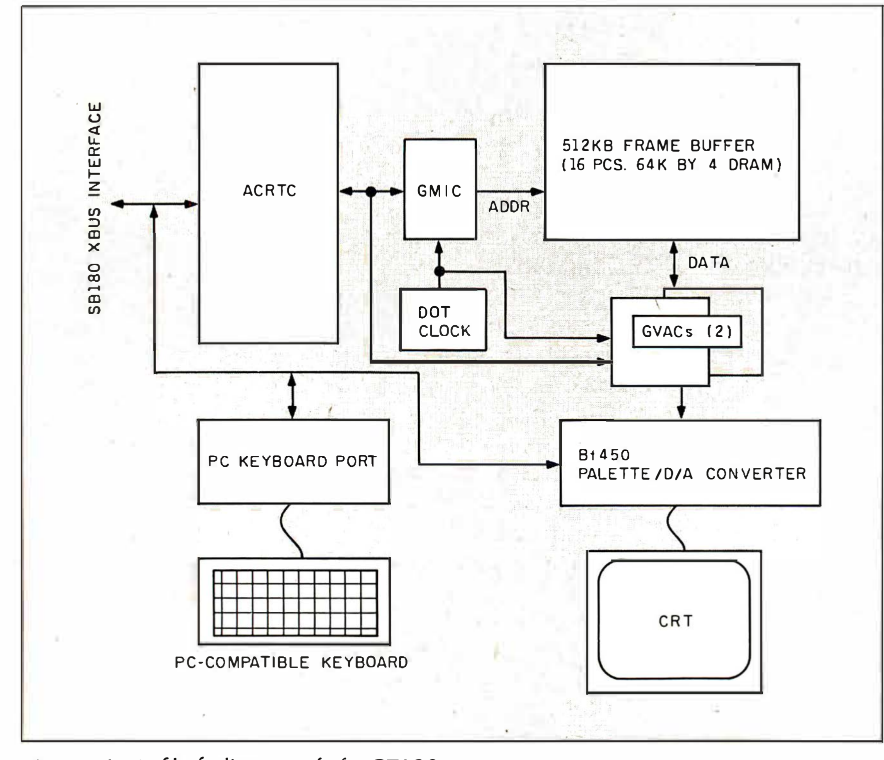


Figure 1: *A block diagram of the* GT180.

CRT Basics

While other display technology comes and goes, the dominant device remains the standard CRT. The underlying technology has been driven by one of the most popular products of all time: the TV set. Many have predicted the end of this glass dinosaur at the hands of other technologies (LCD, plasma, electroluminescence, etc.), but reports of the CRT's demise may be exaggerated. (I tend to use CRT to describe both the glass display tube and the entire terminal display unit with driver electronics.)

The basic principle of CRT operation is simple: An electron beam scans the CRT screen, which is coated with a phosphor. Where the beam hits the phosphor, light is generated. By varying the intensity of the beam, the amount of light generated changes accordingly. In the simplest case (monochrome), the beam is either on or off—each point on the screen is either illuminated or not.

The scanning pattern of the beam

is similar to the way you write with a pencil on a piece of paper. Starting at the top left corner, the beam scans to the right edge of the screen at which point the beam is brought back to the left edge of the screen, one line down from the top. This left-to-right scanning proceeds down the screen until the beam reaches the bottom right corner, then the beam is repositioned at the top left corner and the whole process repeats.

The process of repositioning the beam is called *retrace*. Repositioning from the right edge of the screen to the left edge on the next line down is called horizontal retrace. Repositioning from the bottom right corner to the top left corner is called vertical retrace. The beam is *blanked* (turned off) during retrace, just as your hand is raised off the paper when you reposition the pencil.

As you might guess, the signal that causes the CRT monitor to perform a horizontal retrace is called horizontal sync (HSYNC), and the signal that causes the CRT monitor to perform a vertical retrace is called vertical sync (VSYNC). An important point to realize is that the times at which horizontal and vertical retrace occur are the responsibility of the video-signal generator and not the CRT screen or monitor electronics (see figure 2).

It is important that the controller provide HSYNC and VSYNC timing within the limits specified by the CRT. Some CRTs will self-destruct if sync timing is incorrect! In the case of a computer, the video controller sync timing is generally software-programmable to allow for compatibility with different CRTs. This means the CRT has the distinction of being one of the few pieces of computer hardware that might be physically destroyed by software bugs. Read and heed!

CRT TIMING

Scan timing involves a number of constraints. First, the CRT phosphor, like a dynamic RAM, needs to be refreshed. As soon as the beam passes a point on the screen, the image at that point will begin to fade. If the refresh period (time between consecutive beam passes) is too slow, the

(continued)

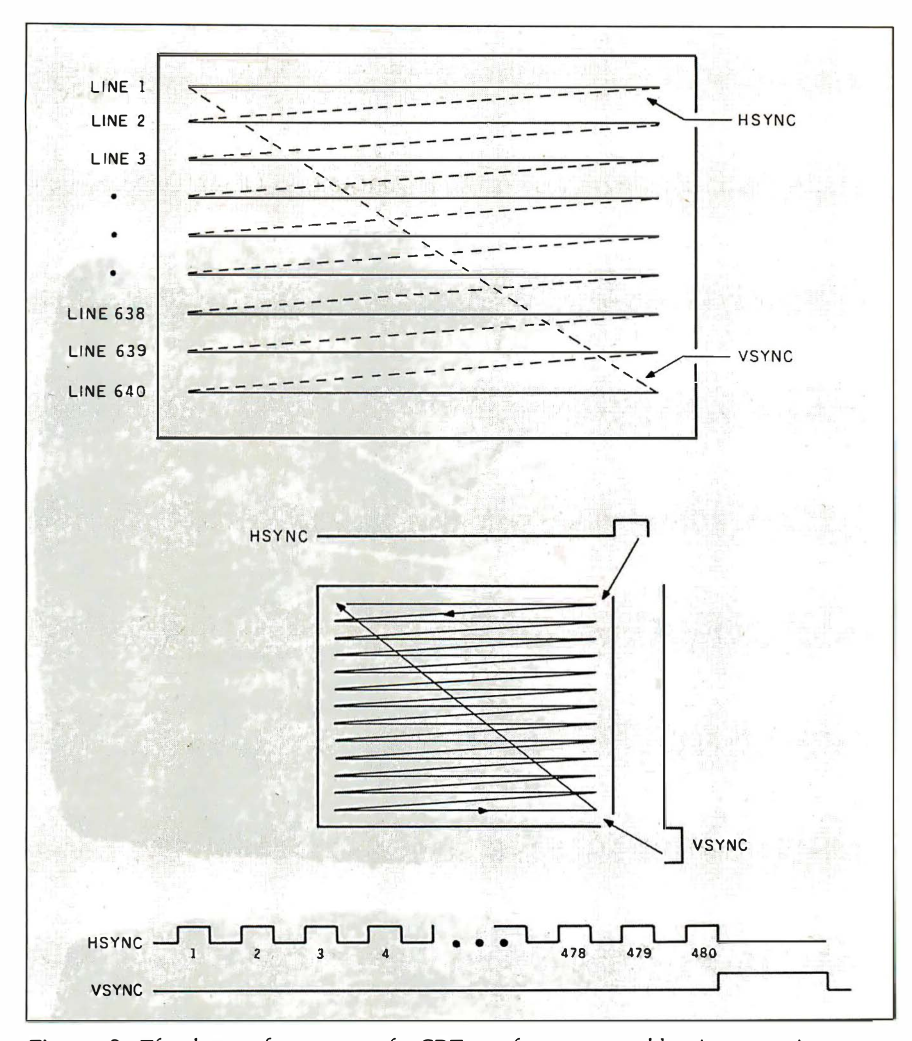


Figure 2: *The electron beam scans the* CRT *much as you would write on a piece of paper.* HSYNC *causes the beam to perform a horizontal retrace;* VSYNC *causes it to perform a vertical retrace.*

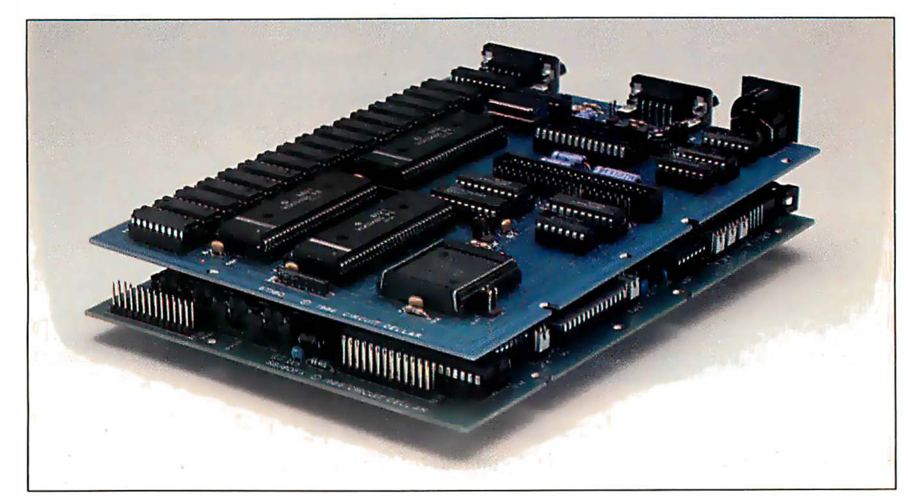
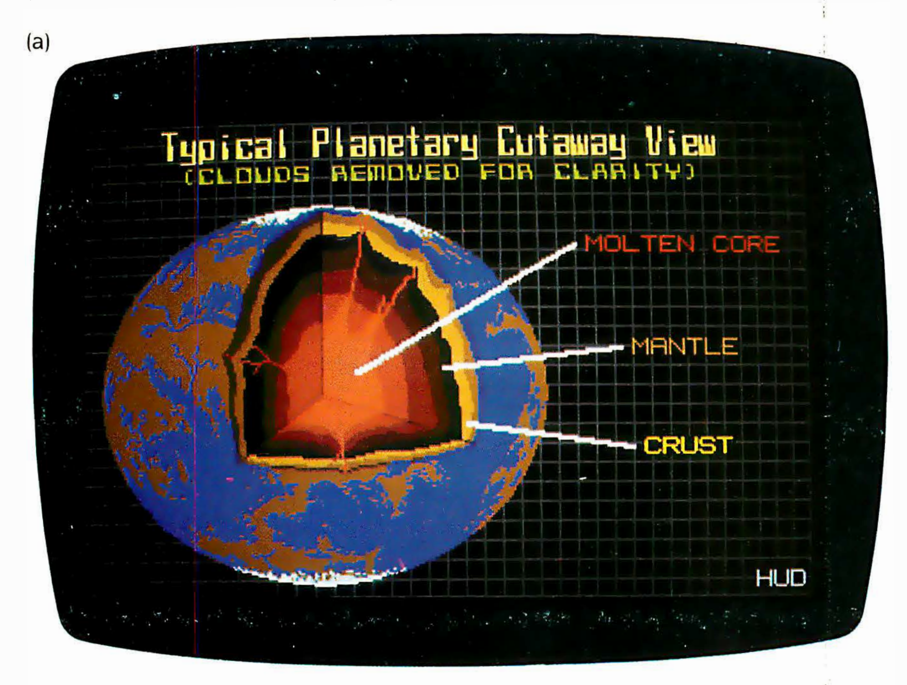


Photo 1: *The* GT180 *board attached atop the new* SB180FX *single-board microcomputer. (The* SB180FX *is an enhanced version of the* SB180. *See the September* 1985 *Circuit Cellar for a description of the* SB180.)

result will be an annoying flicker as each point cycles through the refresh-fade sequence.

One solution is to use a special CRT phosphor characterized as *long persistence*—this means the phosphor fades more slowly, allowing longer times between refresh before flicker becomes noticeable. Unfortunately, a phosphor with a persistence that is too long produces an effect that is just as annoying as flicker: smear. When the picture on the CRT changes, a ghost of the previous image persists. If the CRT is updated quickly, detail is lost as each new image is superimposed on the vestiges of the past images.

(a)



(b)

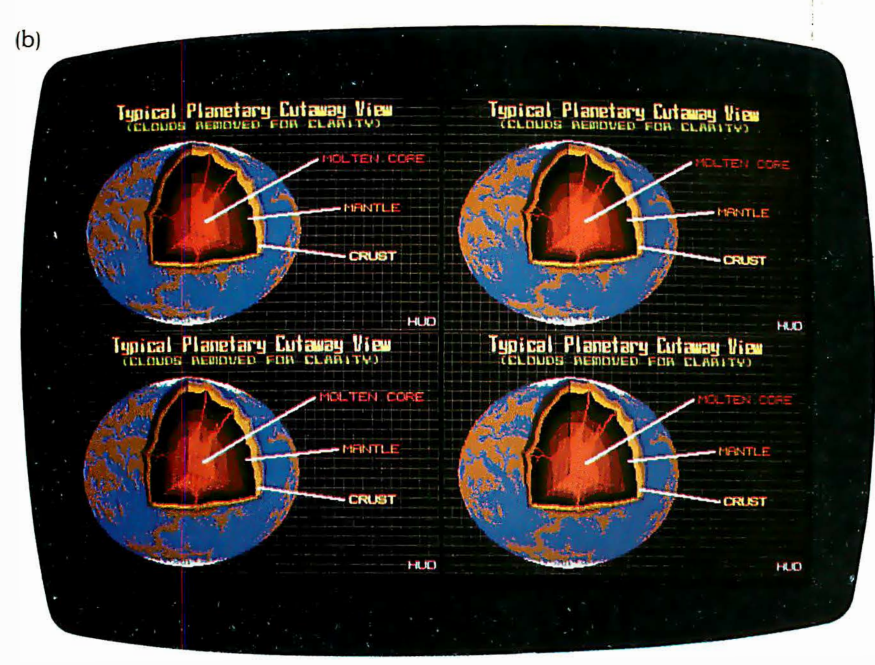


Photo 2: *The resolution and graphics capabilities of the* SB180 *are best illustrated by borrowing a few bit maps from another computer. (a) A standard* 16*-color* Atari 520ST *bit-mapped picture with* 320- *by* 200*-pixel resolution. By setting the* GT180 *to a resolution of* 640 *by* 400, *four* Atari *pictures can be put on a single screen. The result is shown in (b). The* GT180 *can be set to a display resolution as high as* 720 *by* 500.

Therefore, the first major constraint can be characterized as the number of times the beam sweeps the entire screen per second (i.e., the number of VSYNCs per second). It's clear that faster is better, since a short-persistence phosphor (fast updating with no smear) can be used while avoiding the threshold of perceivable flicker. Most commonly, designers choose 60 hertz (60 VSYNCs per second) because this provides a good performance, matches standard phosphor characteristics, and is easily derived from the 60-Hz component of the AC power line (within the U.S.). High-performance (and high-price) systems may offer faster vertical scan rates (i.e., 65–80 Hz).

Since we want to sweep the entire screen, line by line, 60 times each second, a rough calculation shows that very high speed is required. After all, an enhanced screen (640 by 400) contains 256,000 dots. If we insist that the dots be refreshed 60 times a second, that means the video controller must transmit more than 15 million dots per second!

The scanning technique discussed so far, in which each line on the screen is scanned sequentially, is called noninterlaced. To ease the high-speed timing constraints, some systems often use another scanning approach: interlaced. In this scheme, the beam still scans the entire screen at 60 Hz. However, instead of scanning every line during a sweep of the screen, half the lines are scanned, reducing the amount of information that must be transmitted. In fact, conventional TVs use interlaced scanning; although the picture contains 525 lines, only half of them are refreshed each 1/60 of a second. (Note: Actually, not all lines are displayed on the TV screen; some contain supplementary information like closed captions for the hearing impaired and stereo audio.)

If you've followed the previous discussion, you may have deduced that

TV sets must use a long-persistence phosphor to ensure that flicker doesn't occur. The price you pay for the long-persistence phosphor is some smear, but objects on TV are moving slowly enough so that the effect is unnoticeable. Unfortunately, the same cannot be said for computer images, in which operations like scrolling quickly highlight the smear effect. Generally speaking, high-performance computer displays use only noninterlaced scanning.

Accepting the 60-Hz noninterlaced vertical scan, the other important CRT timing considerations include the horizontal scan rate and video bandwidth. Together, these three parameters dictate the actual resolution (i.e., the number of dots that can be displayed on the screen).

As the vertical scan rate (60 Hz) corresponds to the rate of VSYNC, the horizontal scan rate corresponds to the rate of HSYNC. Given the constraint of scanning all the lines of a screen in 1/60 of a second, you can see that for a given line width, the number of lines that can be displayed on the screen is directly related to the speed with which each line is horizontally scanned. For example, older displays like the IBM CGA, which have a resolution of 640 by 200, use a horizontal scan rate of 15.75 kilohertz. Similarly, displays with a resolution of 640 by 400 have a horizontal scan rate of 31.5 kHz.

The final CRT timing parameter is known as bandwidth or dot rate. This refers to the timing of the actual video signal that modulates the electron beam in the CRT. This is influenced by a number of factors, including the CRT video-signal input circuits and the response time and accuracy of the electron gun. The higher the required resolution, the higher the bandwidth needed. A 640 by 200 noninterlaced 60-Hz CRT typically requires a bandwidth of about 15 megahertz, while a similar 640 by 400 CRT needs 30-MHz bandwidth.

Although CRTs have a number of other timing parameters (like sync pulse widths), the three primary parameters—vertical scan rate, horizontal scan rate, and bandwidth—along with scan mode (interlaced or noninterlaced) define the overall performance envelope.

Monochrome vs. Color

Previously, we assumed that a single scanning electron beam could take only two states: on or off. In fact, this is the case for a monochrome display like the Macintosh. Achieving a color display is an elaboration of the same basic scheme. Two changes must be made: The CRT must be able to display multiple colors, and the video controller must provide color information for each dot.

The most prevalent technique for making color CRTs (and color TVs) is to replace the single electron beam with three beams and to coat the CRT face with three phosphors. Each beam/phosphor is responsible for generating a different color: red, green, and blue. You can generate eight different colors by combining red, green, and blue. For instance, you produce a white dot by turning the red, green, and blue beams on simultaneously.

The video controller must also provide three signals, instead of the single signal required for monochrome. In fact, a fourth signal, intensity, is often provided, giving the effect of 16 possible colors instead of 8. For example, white is red+green+blue with intensity on; gray is red+green+blue with intensity off. This type of CRT is referred to as an RGBI monitor.

Digital vs. Analog

In the previous discussion, for both monochrome and color, the video signal (one signal for monochrome, four signals for RGBI) was assumed to take one of two states: on or off. This is called a digital TTL monitor.

An analog monitor adds the capability to modulate the electron beam(s) to intermediate levels between on and off. For a monochrome monitor (one video-input signal), this allows various shades of gray. For a color monitor (three video-input signals: R, G, and B), it allows various tints and hues. The visual results are much more pleasing than those of digital monitors. TV sets use this approach. Moving upscale from monochrome to either digital color or analog color is just a matter of more memory and more speed—no problem in this era of VLSI.

The vertical scan rate, the horizontal scan rate, and the video bandwidth dictate the actual resolution.

The Frame Buffer

I have explained how a CRT turns video signals into pictures on the screen. Where does the video signal come from?

In the case of a conventional TV receiver, the video signal comes from a station transmitter and is captured by the receiver in the TV for display. The TV station transmits a continuous stream of display frames, eliminating any requirement for video-frame retention or buffering in the TV receiver.

The computer holds a digital representation of the screen in a special memory called the frame buffer. Display circuits in the computer extract and condition this video information to generate the video signal(s) required to recreate the image on the CRT screen. A key part of this function is parallel-to-serial conversion. The display controller pulls a number of bits (8, 16, 32, or more) from the frame buffer at once and shifts them out as a serial video signal. The shift clock is also known as the dot clock and corresponds directly to the CRT bandwidth discussed earlier. To change the image on the CRT—a process known as drawing—the drawing processor need only change the contents of the frame-buffer memory (see figure 3).

Bit Mapping

The simplest frame-buffer organization is called bit mapping. In this organization, a bit (monochrome) or bits (color) in the frame buffer are pro-

(continued)

vided for each dot on the CRT screen. The bits in the frame buffer map directly to points on the CRT screen. The minimum amount of frame-buffer memory required is equivalent to the number of dots on the screen times the number of bits required to specify the color information for each dot.

For a monochrome bit map, only 1 bit is required for each dot on the screen. Thus, a 640 by 400 monochrome display requires about 32K bytes. For a 16-color RGBI display, where each dot requires 4 bits of information (R, G, B, and I), a 640 by 400 image requires about 128K bytes.

Palette D/A Converter

For a TTL RGBI color monitor, it is easy to see that 4 bits (R, G, B, and I) are required for each dot on the display. Furthermore, the system is totally digital. The frame buffer contains 1s and 0s, and the CRT itself accepts 1s and 0s (i.e., the CRT R, G, B, and I inputs are either on or off). What is the difference between it and an analog RGB display?

First, there is a difference in the CRT monitors themselves. In a TTL RGBI monitor, the three beams are either at a low or high intensity as defined by the state of the intensity signal. To achieve a greater variety of colors, the intensity of each beam is varied. Instead of on/off TTL levels that would be applied to a TTL RGBI monitor, an analog RGB monitor is sent an analog voltage for each beam.

Within the frame buffer, the color information is still stored digitally, but each dot must now include the intensity settings for each beam as a 6-bit (64 colors), 9-bit (512 colors), or 12-bit (4096 colors) data word. This digital information is converted to analog video-signal levels through a D/A converter.

Since each of the three CRT guns (R, G, B) must be driven independently, we need three D/A converters. Unlike the industrial-control-oriented D/A converters discussed in previous articles, these "video D/A converters" need to be very fast: Bandwidth (the speed with which the D/A converter converts the digital frame-buffer information to an analog video signal) must match that of the CRT. Furthermore, other D/A converter performance characteristics are also strict in order to produce a glitch-free display.

As in the case of the digital monitor, the number of colors that can be displayed is a function of the number of bits in the frame buffer for each dot. Thus, 4 bits/dot means each dot can take one of 16 colors, 8 bits/dot=256 colors, 12 bits/dot=4096 colors, etc. Since the system drives three guns (R, G, B), we normally select a number of bits per dot that is evenly divisible by 3. A typical application might have 12 bits per dot, using three 4-bit D/A converters. Thus, each signal (R, G, and B) can take on 16 levels. The total number of combinations yields 4096 colors.

With that in mind, it would appear that to move up from a 16-color display to a 4096-color display simply requires tripling the frame-buffer size, since each dot now requires 12 bits. While the increased memory is supportable (384K bytes for a 640 by 400 display), unfortunately a substantially higher bandwidth is also required. To

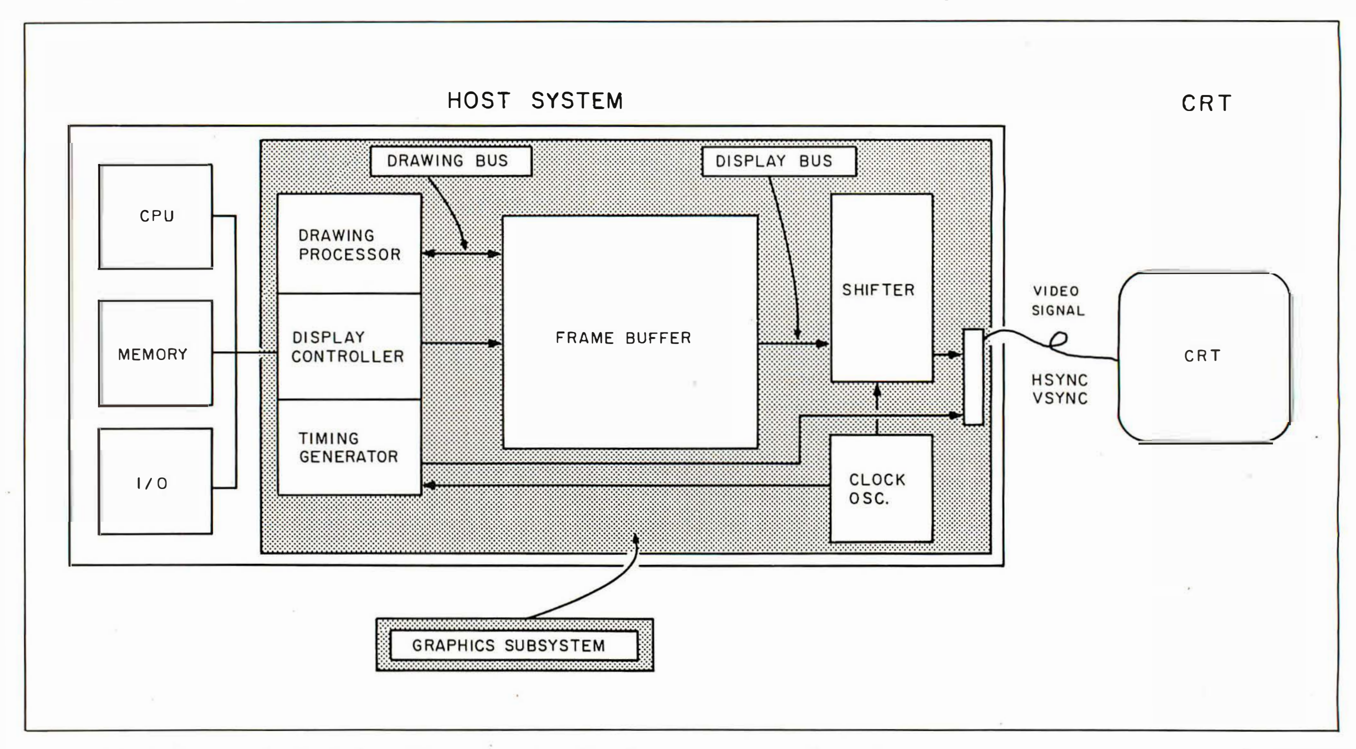


Figure 3: *A diagram of a typical graphics system, including host computer, graphics subsystem, and CRT. Key components of the subsystem are the frame buffer, drawing processor, display controller, timing generator, and shifter. Data is read in parallel fashion from the frame buffer by the display controller, which passes it to the shifter to be serialized into the video signal. The timing generator controls basic system timing and generates the* HSYNC *and* VSYNC *control signals.*

display a dot on the screen, 12 bits (4096 colors), instead of 4 bits (16 colors) or 1 bit (monochrome), must be pulled from the frame buffer to refresh each dot on the screen 60 times a second.

As we calculated earlier, for a 640 by 400 monochrome display with 60-Hz vertical scan, we need to extract 15,360,000 bits from the frame buffer each second. While this is fast, most memory ICs and display controllers can handle the required transfer rate of 2 megabytes per second. With 12 bits instead of 1 bit per dot, however, the speed requirement increases twelvefold! Instead of 15.36 megabits per second, the system must extract 184 megabits per second (23 megabytes per second)! This is too fast for most microcomputers.

The solution is to use a device called a palette D/A converter. Like an artist's palette, this device provides the total range of color possibilities, even if we can use only a few of them at one time. The technique is straightforward: The typical palette RAM, like the Brooktree BT450, is organized as 16 cells, each containing 12 bits of data. Within the 16 cells are stored 12-bit values representing 16 of the 4096 possible colors (these 16 cells are loaded by the CPU prior to a video scan). Each dot on the display is defined by a 4-bit value in the frame buffer. These 4 bits serve as an address selecting one of the 16 palette entries. The 12 bits stored in the selected cell are in turn presented to three 4-bit D/A converters connected to the RGB lines (see figure 4).

While the 16 colors available through a palette D/A converter may seem to offer no improvements beyond a 16-color RGBI system, remember that we can choose 16 of 4096 colors. It is possible for the CPU to change the contents of the palette D/A converter at the end of each horizontal scan line. Rather than showing only 16 colors then, an entire screen can display all 4096 colors. Reloading the palette can create some interesting effects. For example, the color of a certain area on the screen can be changed by simply changing the corresponding palette entry—this is considerably faster than actually changing the color of each dot in the frame buffer.

Split Screens and Windows

A powerful visual interface like the Macintosh depends on graphics techniques like split screens and windows to implement popular features like pull-down menus, dialog boxes, and application windows. In a simple bit-mapped system, the display controller cycles sequentially through the frame buffer from beginning to end and back to the beginning. In other words, the relative position of an image on the screen corresponds exactly to its relative position in the frame buffer. To move a window on the screen requires physically moving the associated image in the frame buffer. If you shrink or move a window on the display, you must also restore the newly uncovered background.

Having the host CPU responsible for all this is possible, but problems emerge as the amount of information to be moved increases. The screen response for tasks like dragging a window can become annoyingly sluggish. In any case, CPU cycles devoted to screen housekeeping can be used for more useful work.

Adding intelligence to the display controller provides hardware split screens and windows. This feature requires that the display controller, instead of scanning in a fixed sequential order, be able to scan different areas of the frame buffer at will. The programmer defines the physical position on the screen of a split or window. Then the display controller monitors the physical location being displayed and accesses the appropriate location in the frame buffer. This allows the various pieces of the screen image (menus, dialog boxes, windows, etc.) to be stored in separate areas of the frame buffer—the hardware will automatically put each piece in the right place on the screen (see figure 5). Moving a screen image becomes as simple as programming a new start address instead of actually moving each dot. (Note that I am implying that the frame buffer may be

Moving a screen image becomes as simple as programming a new start address instead of actually moving each dot.

(continued)

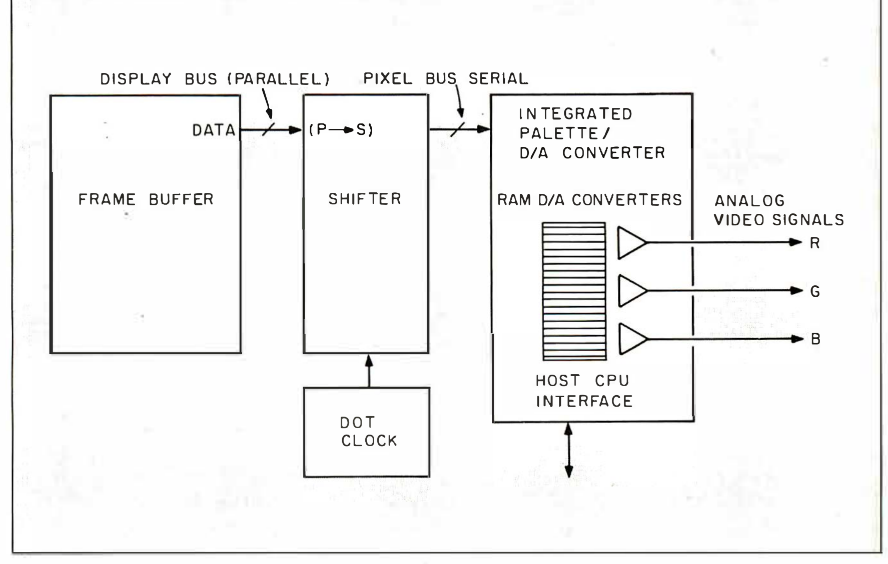


Figure 4: *New integrated palette D/A converters, like the Brooktree BT450 used on the GT180, combine a number of functions formerly requiring separate chips.*

larger than can fit on the screen at one time.)

DRAWING

The process of writing into the frame buffer is called drawing, while the process of reading from the buffer to the CRT is called display. The drawing and display processes contend for access to the frame buffer. One way to resolve such contention is to use dual-port RAMs for the frame buffer. Another approach is timeshared access to a single-ported frame buffer.

In any case, the application programmer needs to be able to move pictures in and out of the frame buffer and issue commands like LINE, CIRCLE, PAINT, WINDOW, and ZOOM. Ideally, the programmer can use logical *x,y* coordinate addressing, rather than being burdened with computing a frame-buffer physical address (e.g., "move the pointer to screen *x,y* position (100,200)" instead of "move the pointer to the dot in the high-order 4 bits of address 1234 hexadecimal"). A myriad of other graphics commands can be imagined for use in a variety of applications.

Opinion has been divided as to whether the host CPU should perform these drawing algorithms, or whether a separate drawing processor should be used. My opinion has always been to do it in hardware, and I think the trend to higher resolution, more colors, and faster response will ultimately lead others to conclude that an intelligent graphics coprocessor is the only way to go.

TRANSPORTABLE GRAPHICS

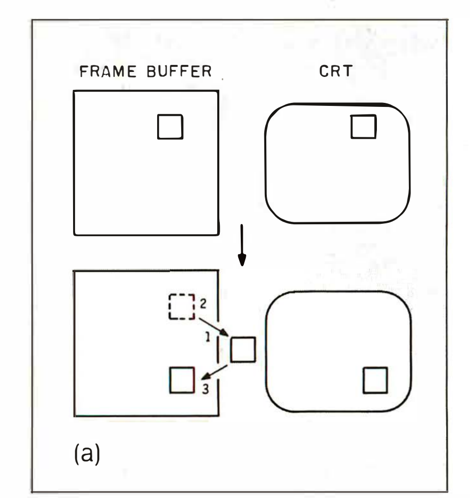
Any graphics system has several distinct command levels. At the lowest level is the hardware: the registers associated with the graphics-display chips used on the display board. At the next level is usually a group of drawing primitives: point plotting and line drawing. Next, a graphics environment like that found in GEM and Microsoft Windows may be defined that provides standard function calls like "draw a box containing this text" or "open this window." At the highest level is the application program that provides the user with commands necessary to complete the task the program was designed to perform.

An ongoing debate is occurring over which of the above levels should be performed by hardware and which should be performed by software. (Most of the systems in use today perform the higher two levels in software on the host system.) Further, there must be, at some level, a standard interface between the host processor and the graphics device. For example, on IBM's CGA card, the hardware level consists of the 6845 registers (the 6845 is the PC's graphics-controller chip). At the primitive level, the BIOS provides simple character output. To remain compatible with the various graphics boards and clones on the market, programs should make calls to the BIOS for character display. Programs that access the 6845 directly may run into problems.

The Hitachi HD63484 ACRTC takes control of graphics operations one level higher than most graphics boards do. Most graphics boards provide the host processor with a set of registers and perhaps a simple set of drawing primitives in EPROM. The host processor is still responsible for all drawing overhead, including translation of *x,y* coordinates to absolute memory addresses, setting of color information, and calculating each dot for a given line or arc. Consequently, the graphics device/host processor interface takes place at the lowest level: the hardware level.

The ACRTC, however, performs many primitive functions right on the chip. For example, it translates *x,y* coordinates into absolute addresses; draws lines, given the endpoints, boxes, arcs, and ellipses; and performs screen clears and area fills using an optional pattern. All these functions are performed in hardware. Using this as the graphics controller, the graphics device/host processor interface shifts up a notch to the primitive level. The host processor does all its communications with the graphics device via calls to primitives rather than register accesses.

Another issue related to the graphics board/host processor interface is that of how to maintain compatibility when using a program with different kinds of hardware. There are any number of ways to build a graphics controller in hardware that provides a given resolution and number of colors. Each design is bound to use a different graphics-controller chip and, as a result, a different method of communicating with the host processor



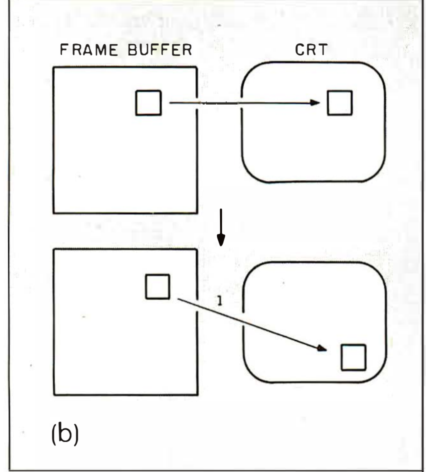


Figure 5: *(a) If the display controller isn't "smart," moving a window requires actually moving the data. The algorithm might require a three-step process: Copy the window contents to a temporary buffer; erase the old window, restoring what was underneath; and copy the window contents to the new location. (b) In a smart display controller, changing a window position is as simple as reprogramming a few display-controller address registers. This method is fast, and the time required to move the window is independent of window size. Also, the hardware window has priority, so what was underneath the moved window reappears.*

(the registers will probably be different between boards).

The primitive level is usually used as a buffer between a higher-level program that uses a standard set of function calls and the hardware that is different between various boards. If the higher-level program stays on its side of the fence and doesn't cross over into the hardware level, it will function properly with every graphics board, regardless of hardware configuration. When the program does start accessing hardware registers specific to a particular graphics board, it will likely have trouble when used with a different board.

The implementation modules for the set of tools used with the GT180 were written with the HD63484 in mind. However, as long as the target graphics board can display the same resolution and number of colors as the GT180, a program written using Borland's Graphix Toolbox (designed to interface via Borland's Modula-2) can be ported with little effort to the new graphics board. The definition modules of all the tools will stay the same, regardless of what machine it is running on. The implementation modules contain all the machine-specific code.

There still hasn't been a graphics standard defined that is widely used in industry. The problem is exacerbated by a graphics technology that grows in leaps and bounds, often opening new frontiers not considered in older standards proposals. The issue of where to place the graphics board/host processor boundary is a constant issue. For example, all the IBM graphics adapter cards require hardware-level programming (even though there are BIOS calls, the processor still must do all the work). With the SB180/GT180, the ACRTC does most of the low-level primitives.

The physical interface between devices must also be considered. Most display adapters plug directly into the backplane, allowing the processor direct access to all hardware registers. The GT180 also plugs directly into the SB180's XBUS, but the processor must talk to the ACRTC through a pair of I/O ports, even though the ACRTC does have internal registers. The host processor doesn't need to access the hardware registers often (if at all). Since this graphics device/host boundary is at a higher level requiring less information exchange, it is easier to merely send the ACRTC a stream of drawing commands.

The real problem of defining a graphics standard comes down to defining a set of commands that is rigid enough to allow simple program transportation and that takes hardware differences into account while allowing the programmer to take advantage of any special features of the graphics processor. There is no easy solution, as evidenced by the lack of a widely accepted graphics standard. I hope that the SB180/GT180 with Modula-2 and Graphix Toolbox will make the waiting more constructive.

Circuit Cellar Feedback

This month's feedback begins on page 58.

Next Month

Part 2 looks at the GT180 hardware. ■

Special thanks to Tom Cantrell, Ken Davidson, and Mike Weisert for their contributions to this project.

All screen pictures presented in this article were produced using the GT180 with a Princeton SR-12P monitor. The bit-mapped pictures were originally composed on an Atari 520ST using DEGAS by Tom Hudson. They are reproduced and used here by permission.

The following items are available from

The Micromint Inc.
25 Terrace Dr.
Vernon, CT 06066
(800) 635-3355
(203) 871-6170
Telex: 643331

1. GT180 graphics board: RGBI version less palette D/A converter. Comes with demo disk and user's manual.
   board alone $395
   board with Modula-2 and GT180 Graphix Toolbox $449
2. GT180 graphics board: RGBI and analog version with palette D/A converter. Comes with demo disk and user's manual.
   board alone $449
   board with Modula-2 and GT180 Graphix Toolbox $499
3. Borland International Turbo Modula-2 and GT180 Graphix Toolbox software for the SB180 and SB180FX computers, optimized for the 64180 processor. Supplied on 5¼-inch DS/DD SB180 format disks with 300-page manual.
   SB180 Modula-2 alone $69
   SB180 Modula-2 with Graphix Toolbox alone $89
4. SB180FX 5.75- by 8-inch single-board computer, accommodates 512K bytes of memory, two serial ports, three parallel ports, parallel printer port, floppy disk controller, SCSI controller, ROM monitor, 6-MHz 64180. Comes with ZRDOS, ZCPR3, hard disk BIOS, and user's manuals. Populated with 256K-byte memory, less 53C80 SCSI controller chip.
   SB180FX board alone $409
   SB180FX board with software $499
   9.288-MHz 64180 processor upgrade (SB180FX only) $50

GMIC, GVAC, ACRTC, and palette D/A converter chip sets are available for experimenters who wish to hand-assemble the GT180. Call for price and availability information. Borland Turbo Modula-2 is also available for most CP/M Z80 machines. Consult regular CP/M and 8-bit software distributors for various disk formats and prices. The SB180FX is hardware- and software-compatible with the SB180.

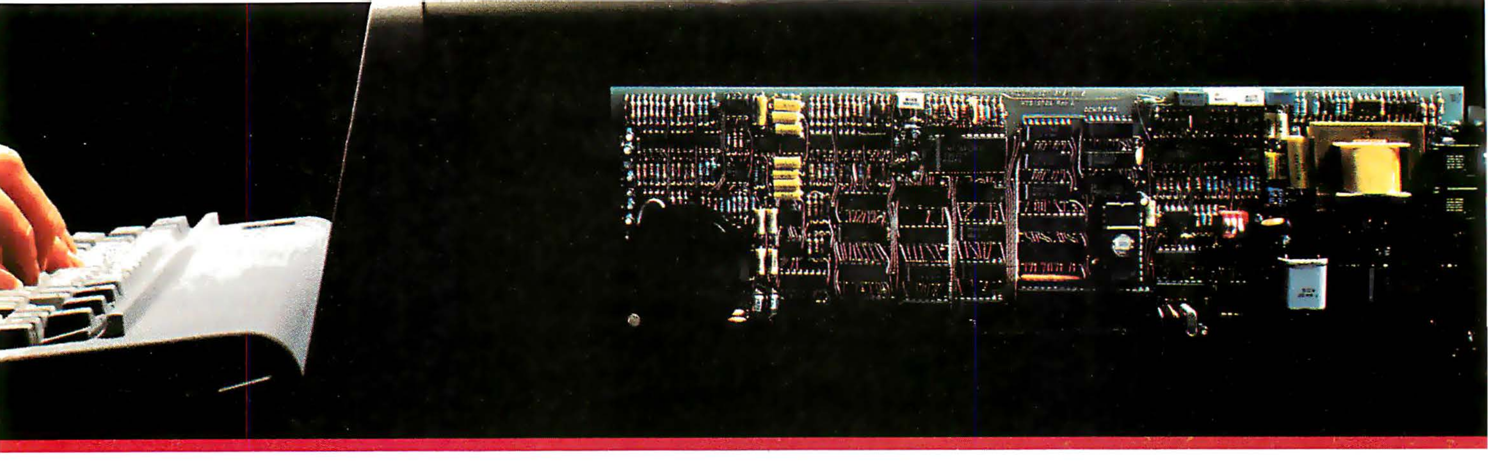
Surface delivery (U.S. and Canada only): add $5 for U.S., $10 for Canada. For delivery to Europe via U.S. airmail, add $20. Three-day air freight devlivery: add $8 for U.S. (UPS Blue), $25 for Canada (Purolator overnight), $45 for Europe (Federal Express), or $60 (Federal Express) for Asia and elsewhere in the world. Connecticut residents please add 7.5 percent sales tax.

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Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume* II covers December 1978 through June 1980. *Volume* III covers July 1980 through December 1981. *Volume* IV covers January 1982 through June 1983. *Volume* V covers July 1983 through December 1984.

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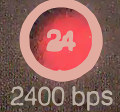


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EXTRACTING THE *n*th ROOT FROM A BINARY NUMBER

BY LAU SIU WO

A general algorithm for extracting real roots

I HAVE DEVELOPED a general algorithm for extracting any real root from a binary number. Figure 1 shows the mathematical justification for the procedure.

To begin, the binary number whose *n*th root you want to take should be divided into groups of *n* bits from the least significant bit out. Thus, if *n* does not evenly divide the number of bits, the most significant bits group will contain fewer than *n* bits.

First, you save 1 as the most significant bit of the root and subtract 1 from the most significant group of bits. Append the next *n*-bit group to the remainder to make a new number, *REM*, and calculate the comparator *CMPR* $|(2R+1)^n-(2R)^n|$, as explained in figure 1. If $REM \geq CMPR$, then the next bit of the root is 1 and the new remainder is $CMPR-REM$. If $REM < CMPR$, the next bit of the root is 0 and the remainder is left untouched. To obtain the succeeding remainders, shift the previous remainder *n* bits

(continued)

Lau Siu Wo is a lecturer on computer-aided engineering in the integrated circuit design department of the French-Singapore Institute. He can be reached at 12 Science Centre Road, Jurong, Singapore 2260, Republic of Singapore.

Let $X_n, X_{n-1}, X_{n-2} \ldots$ and R_1, R_0 be the binary digits of two numbers such that

$$X=2^nX_n+2^{n-1}X_{n-1}+\ldots+2X_1+X_0,$$

and $R=2R_1+R_0,$

where for all natural numbers of i, R_i, and X_i,

$$1 \geq X \geq 0 \text{ and } 1 \geq R \geq 0$$

and R is the closest *n*th root of X.

Therefore, $X \geq R^n$,

$$\rightarrow 2^nX_n+2^{n-1}X_{n-1}+\ldots+2X_1+X_0 \geq (2R_1+R_0)^n$$

From this we derive the recursive inequality,

$$\rightarrow 2^n(X_n-R_1^n)+2^{n-1}X_{n-1}+\ldots+2X_1+X_0-((2R_1+R_0)^n-(2R_1)^n) \geq 0$$

This inequality suggests that if R_1 is the closest *n*th root of X_n, then the next digit R_0 can be found by making the comparator $(2R_1+R_0)^n-(2R_1)^n$ closest to the remainder

$$2^n(X_n^n-R_1^n)+2^{n-1}X_{n-1}+\ldots+2X_1+X_0.$$

Since X_n is chosen to be nonzero, $R_1^n=1$, and R_0 can be only 0 or 1. For programming convenience, we can always force $R_0=1$ and evaluate whether $(2R_1+1)^n-(2R_1)^n$, the comparator *CMPR*, is smaller than $2^n(X_n-R_1^n)+2^{n-1}X_{n-1}+\ldots+2X_1+X_0$, the remainder *REM*. The recursive property of the previous inequality can be easily shown:

$$\text{if } R = 2^mR_m+2^{m-1}R_{m-1}+\ldots+2R_1+R_0,$$

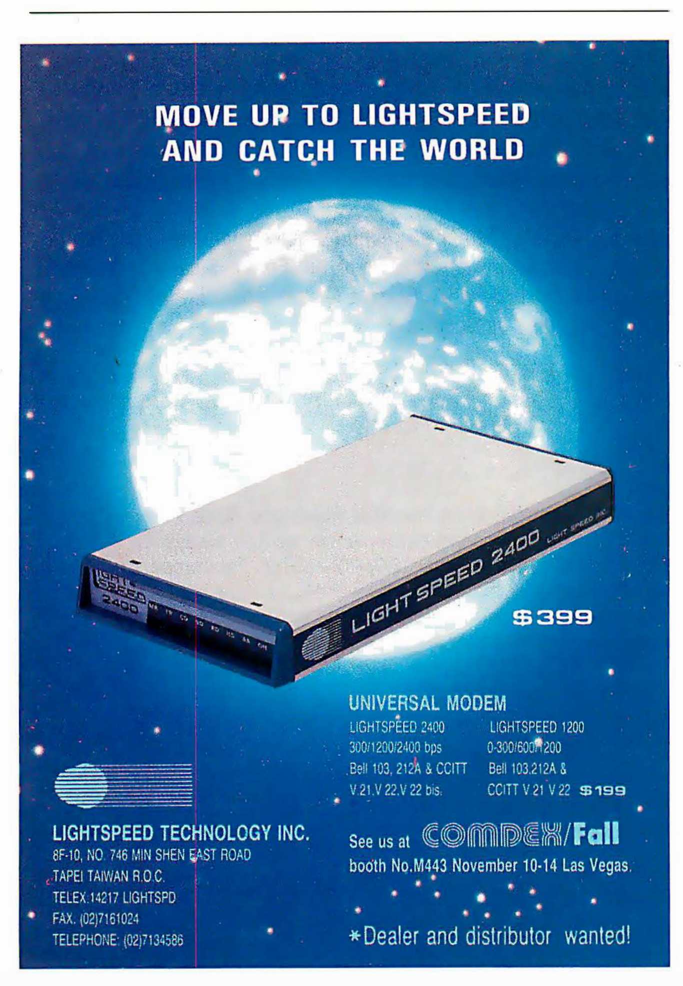
$$X = 2^{nm}X_{nm}+2^{nm-1}X_{nm-1}+\ldots+2X_1+X_0,$$

equating $X \geq R^n$, then the second and succeeding comparator is always

$$(2R+1)^n-(2R)^n,$$

where R is the value of the previous result.

Figure 1: *Derivation of the comparator formula.*




```
R =    1         [?]
     |100 | 1100010 | 0101101  =  78125₁₀
       1
      11    1100010  = REM
```

$CMPR = 3^7 - 2^7 = 2059_{10} = 100000001011_2$

$CMPR > REM$, so [?] = 0

```
R =    1         0          [?]
     |100 | 1100010 | 0101101  =  78125₁₀
      11    1100010   0101101  =  REM
```

$CMPR = 5^7 - 4^7 = 61741_{10} = 1111000100101101_2$

$CMPR = REM$, so [?] = 1

```
R =    1         0          1
     |100 | 1100010 | 0101101  =  78125₁₀
      11    1100010   0101101
      11    1100010   0101101
     ---------------------------
                            0  =  REM
```

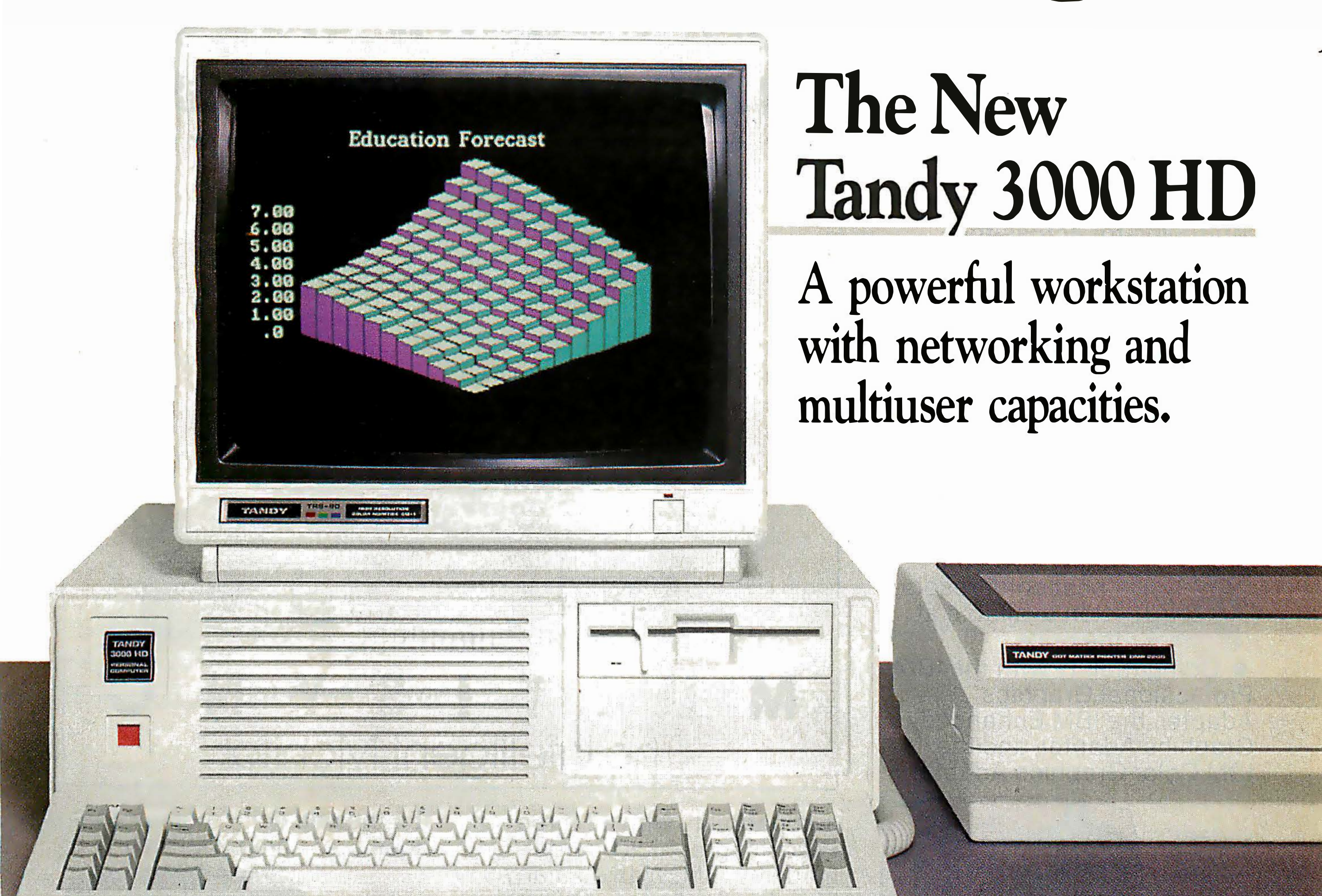
$REM = 0$, so 101_2 is a perfect 7th root.

Figure 2: *Demonstration of the algorithm to take the 7th root of* 78125_{10}, 10011000100101101_2.

to the left and the *n*-bit vacancy with the succeeding group of the number. The calculation loops until the end of the significant bit count is encountered.

To illustrate the procedure, let's take the 7th root of 78125. First, we represent 78125 in binary (10011000100101101) and divide the bits into groups of seven, as shown in figure 2. Next, we subtract 1 from the most significant bit group, leaving 11_2. We calculate the comparator by substituting $R=1$ into the formula and obtain 100000001011, which is larger than the remainder, 111100010. Thus, we enter 0 as the second bit of the root. The next comparator is formed by substituting $R=10_2$ into the formula, which is 1111000100101101. Since the next remainder is the same as the comparator, the last bit of the root is 1. Thus, $R=101_2$, or 5_{10}, and is a perfect 7th root of 78125_{10}. ■

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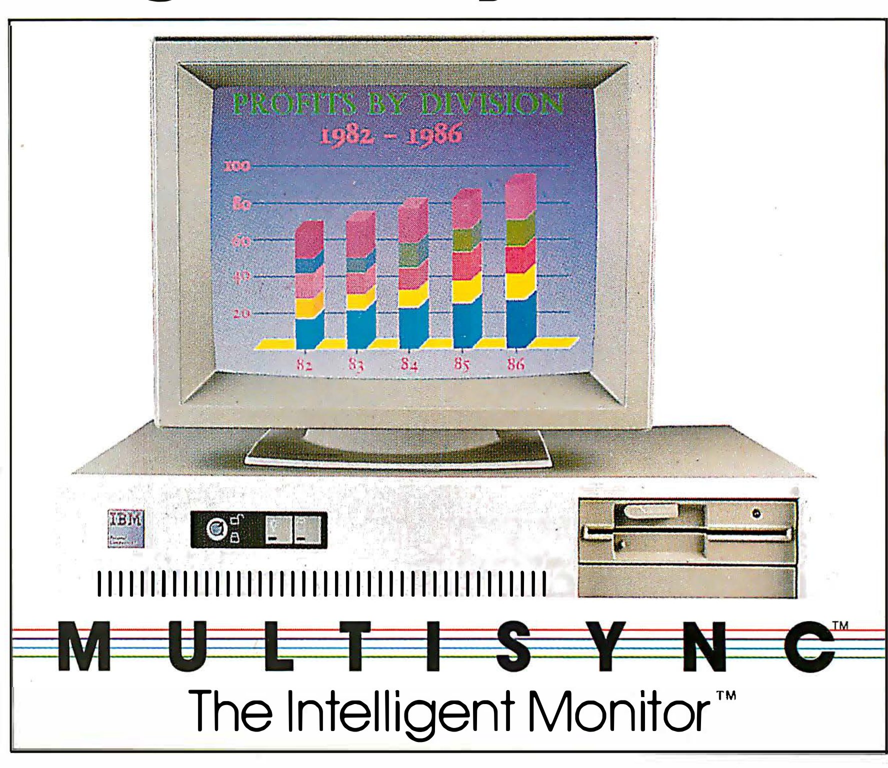
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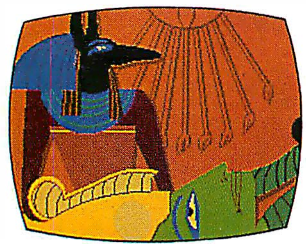
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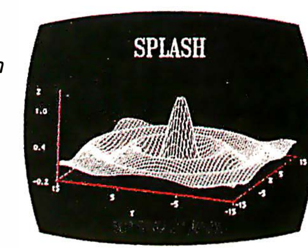
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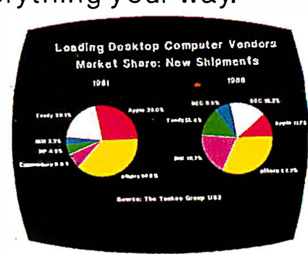
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Inquiry 232

PASSING FILENAMES TO COMPILED BASIC

BY BRUCE HUBANKS

This assembly language subroutine retrieves the command-line text for a compiled BASIC *program*

WHEN YOU START an application program, it is often desirable to be able to specify a filename on the MS-DOS command line. For instance, given a hypothetical data encryption program named Encode, you might like to be able to process a data file named Filex by typing

ENCODE FILEX

Many language compilers provide a library function to retrieve secondary filenames and parameters from the command line. Unfortunately, Microsoft's BASIC Compiler does not.

I have written an assembly language subroutine called Getspec to remedy this deficiency. To make use of the routine from a BASIC application program, you simply include a couple of lines at the beginning of your program, as shown in listing 1. Then compile the program and link it to Getspec. The result will be an executable application. (If you use BASCOM's IO option, you won't even need BASRUN to run the program.)

Because Getspec obeys the Microsoft conventions for parameter passing, it could also be used to retrieve filenames for other language compilers that obey these conventions. (Getspec cannot be used with Microsoft's BASIC Interpreter.)

MS-DOS PROGRAM AND DATA CONVENTIONS

A brief explanation of how MS-DOS handles command-line information will help you understand the program in listing 2.

When a program is invoked from the MS-DOS command line, MS-DOS creates a bookkeeping area called the program segment prefix (PSP) at the lowest available memory location. Within this area, the data transfer area (DTA) contains all the characters typed after the program name.

On entry to the program, the stack pointer (SP) gives the code offset address of the calling program. This address enables the subroutine to retrieve parameters from the calling program and pass values back to it.

Refer to listing 2 as you read the following commentary.

Getspec starts by copying the all-important SP value into BP. [BP]+4 gives the code segment address. The starting address of the PSP can be derived from this code segment address by subtracting 16. Adding 128 gives the start of the DTA, which contains a length byte followed by the specified number of bytes that were typed before the end of the line.

The Getspec subroutine uses the stack information to locate the command-string text in the DTA. The program searches for the first nonblank character and then reads the text up

(continued)

Bruce Hubanks (2701-C West 15th St., Suite 228, Plano, TX 75075) has eight years' experience in computer systems design and is currently designing an artificial intelligence application for military aircraft.

Listing 1: A BASIC *program demonstrating the use of the Getspec subroutine.*

```
10 REM   "FILENAME.EXT"
20 F$ = "            "
30 CALL GETSPEC(F$)
40 PRINT "Text remaining on command string is: ";F$
50 END
```

Listing 2: *Assembly language code for the Getspec program.*

```
; Routine to get a filename from the MS-DOS command line
; using a call from a compiled BASIC program
;
const segment word public 'const'
const ends
;
data  segment word public 'data'
data  ends
;
dgroup         group   data,const
;
code  segment byte public 'code'
      public  getspec
      assume  cs:code,ds:dgroup
;
getspec        proc    far
;
      push    bp                 ; save registers
      mov     bp,sp
      push    ax
      push    si
      push    di
      push    dx
      push    cx
      push    bx
      push    es
      push    ds
;
      mov     dx,[bp]+4          ; Get code segment address.
      sub     dx,10h             ; Adjust to PSP address
      mov     ds,dx              ; Move PSP to ds.
;
; Set up pointer to dta to get parameters.
      mov     si,0080h           ; Point to string length and
      mov     cl,[si]            ; check that many bytes.
      mov     ch,0               ; Make cx 16-bit.
      inc     si                 ; Skip over length byte.
;
; Scan past the spaces.
      mov     al,' '             ; Skip spaces.
getspec1:
      cmp     [si],al            ; Check for spaces.
      jne     getspec2           ; Exit loop if not a space.
      inc     si                 ; Otherwise point to next.
      loop    getspec1           ; Loop back for next byte
      jmp     getspec3           ; unless max is exceeded.
;
; move the rest into place
 getspec2:
       mov     bx,[bp]+6          ; Get address BASIC string.
       pop     ds                 ; Get original ds value.
       mov     di,[bx]+2          ; Point to start of string
       push    ds                 ; Put ds back to PSP segment
       mov     ds,dx              ; address.
       cld                        ; Forward direction.
       rep     movsb              ; Make the transfer.
       clc                        ; No error, so clear carry
       jmp     getspecexit        ; and return.
 ;
 getspec3:
       mov     ax,20              ; No file was specified.
       stc                        ; Error, so set flag.
                                  ; and exit.
 getspecexit:
       pop     ds
       pop     es
```

(continued)

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```
        pop     bx
        pop     cx
        pop     dx
        pop     di
        pop     si
        pop     ax
        pop     bp
        ret     1*2
;
getspec         endp
code    ends
        end
```

to the first blank or the end of text, whichever comes first. The nonblank characters are copied into a string that was defined in the main BASIC program. The string storage location is at the address given by [BP]+6.

In the demonstration program of listing 1, F$ receives the filename from the subroutine. The demonstration program allocates 12 bytes to F$—enough to contain a filename—but you can allocate up to 255 bytes to F$ if your application program needs to retrieve additional parameters from the MS-DOS command line.

LINKING GETSPEC TO YOUR PROGRAM

To incorporate Getspec into an existing program, create a source file that matches the one shown in listing 2. Use an assembler to generate an .OBJ file.

At the beginning of your application program, define a string constant to contain 12 blanks (you can use more if they are needed). Use the statement

CALL GETSPEC(F$)

to call the subroutine and get the necessary text into F$.

Compile your BASIC program to produce an .OBJ file. Finally, link the two .OBJ files into a single .EXE file.

Here is a typical command sequence, given two source files named DEMO.BAS (listing 1) and GETSPEC.ASM (listing 2):

```
MASM GETSPEC
BASCOM DEMO/O
LINK DEMO+GETSPEC
```

The /O parameter tells BASCOM to create a single executable file called DEMO.EXE that contains all needed libraries.

Typing DEMO FILENAME.EXT activates the program, which should produce the message "Text remaining on command string is: FILENAME.EXT." ■

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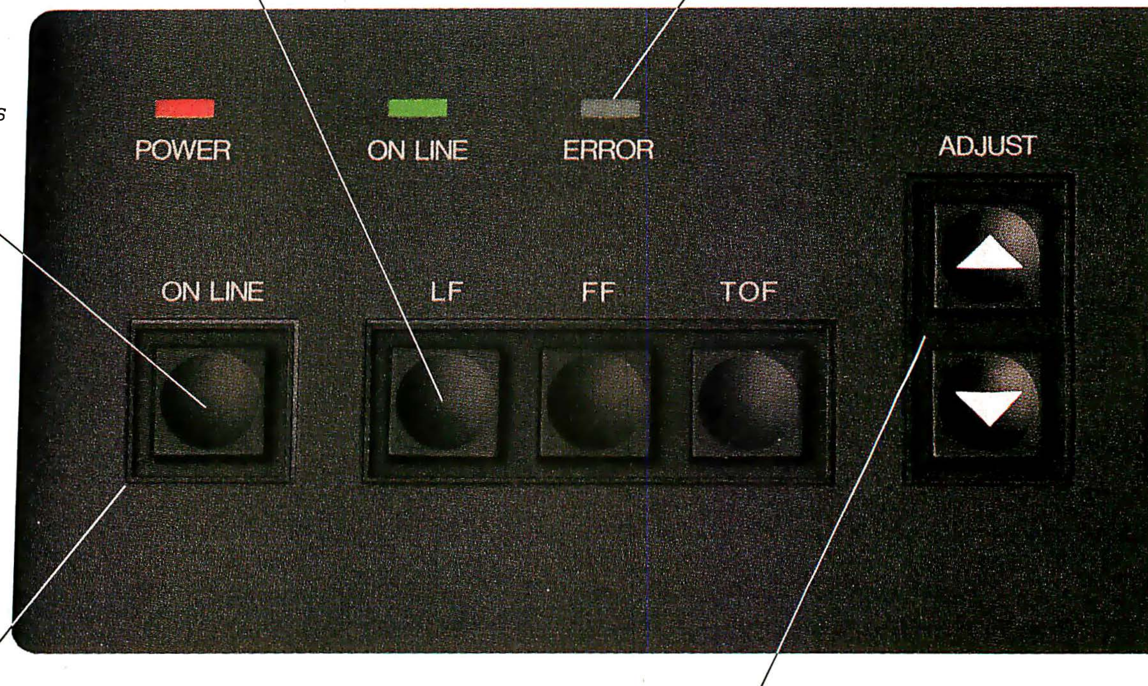
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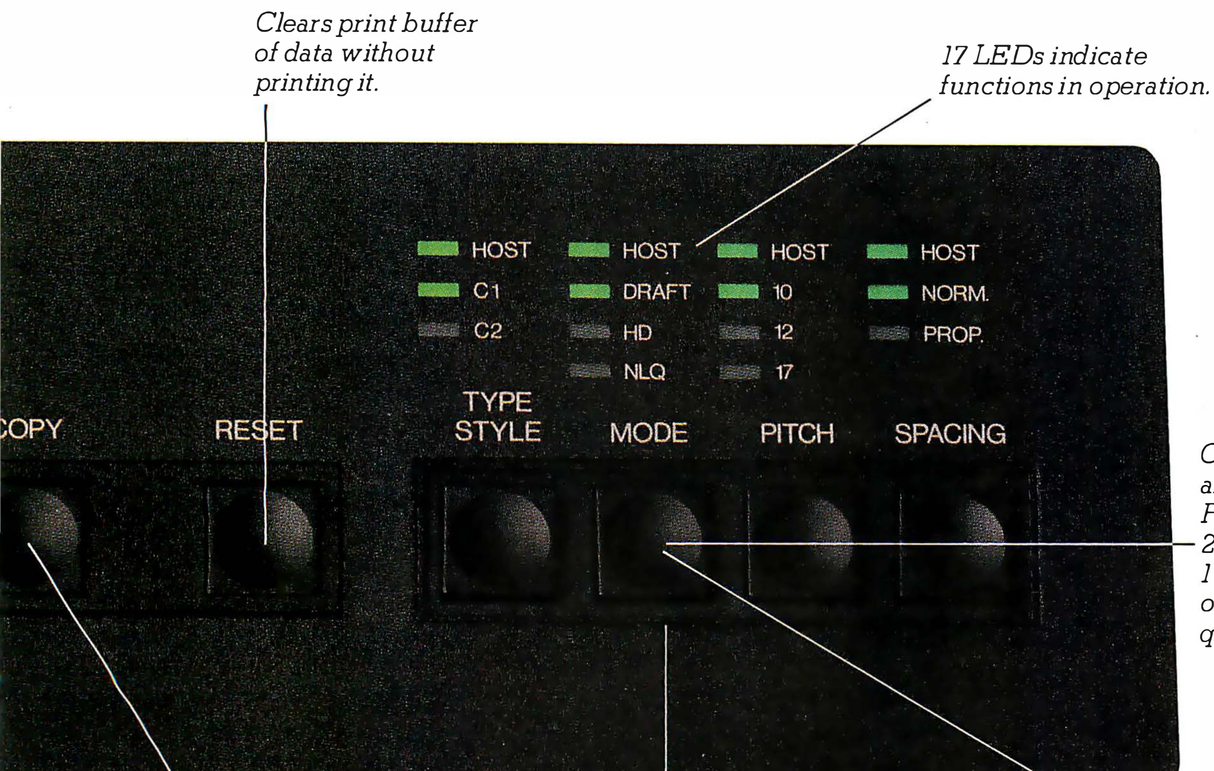
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BY GREGG ZEHR

MEMORY MANAGEMENT UNITS FOR 68000 ARCHITECTURES

Design options that speed up memory management

The Motorola 68000 family of microprocessors has spawned a whole new group of computer systems. The original 68000, with its large, linear addressing range, makes it a natural for single-user, personal graphics workstations such as the Macintosh. And multiuser systems based on the 68020 can offer computing power and speed that rival many minicomputers—often at a fraction of the cost. Not surprisingly, many of the design features for these larger systems have evolved from well-established minicomputer architectures. Memory management units, or MMUs, are one example. The MMU function came about as minicomputer designers began to include special hardware to expand the amount of addressable memory. MMUs have now become a key feature in modern computer architectures. In fact, several MMUs designed specifically for the 68000-family architecture are available (see table 1).

THEORY OF OPERATION

The MMU functions at a very low level in the computer system. Unlike a UART or other peripheral chip that attaches to the system bus and is idle most of the time, the MMU attaches directly to the CPU address bus and intercepts each CPU read or write cycle. The CPU and MMU combine to form a new functional unit. Several manufacturers have even moved the MMU onto the same silicon as the CPU, in effect declaring that you can't have one without the other.

The most important function provided by all MMU designs is the ability to relocate a program to another part of memory according to a set of pre-assigned translation rules. This relocation is done in hardware, without requiring any modification to the application software.

Before a system with an MMU runs a program, the operating system configures the MMU so that the program can be moved to and run in an available section of memory. The program then begins execution, unaware of the MMU's actions. For example, if a program has been compiled and linked with a starting location of 400 but that location is being used for some other purpose, the operating system configures the MMU hardware to convert all the program's memory references to an unused section of memory. Although the MMU is obviously useful in a system that has multiple users running separate programs, it is just as useful in a multitasking single-user system.

In a simple 68000 system that does not have an MMU (figure 1), a typical memory read cycle begins when the CPU asserts an address and address strobe (AS), and the cycle ends when the memory places data on the data bus and activates the data transfer acknowledge (DTACK) line. Assuming that the memory is very fast, the cycle can be completed in eight transitions of the clock, or 500 nanoseconds for an 8-MHz CPU.

In a 68000 system that has an MMU in series with the CPU's address bus (figure 2), for each read cycle the CPU asserts a logical address and logical address strobe (LAS). (The address and address strobe lines are now

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prefaced with the term *logical* since they are the absolute addresses from the CPU's point of view.) The MMU accepts the address and logical address strobe and then translates the logical address according to a set of translation rules into a physical address. It then asserts a physical address and a physical address strobe (PAS). (The term *physical* is used to indicate that these addresses are physically attached to the memory.) The memory again responds by putting data on the data bus and asserting DTACK.

But, as the saying goes, nothing is free. There are two penalties for attaching the MMU in series with a bus—speed and pin count. First, each memory cycle must now be slowed down while the MMU performs the translation. Second, the MMU must monitor a wide input bus and drive a wide output bus. Expect a single-chip MMU for a 68000/68010-based system to have at least 64 pins and an MMU for the 68020 to have over 120 pins. Although the cost of a device is directly proportional to the number of pins on the package, in most systems, fortunately, the cost of adding MMU hardware is less than developing a layer of software to perform similar functions.

Since the MMU operates on each memory access, it is the perfect place to add special hardware support for certain operating system functions that are not strictly related to address translation. The most important extras are memory protection, cache, and virtual memory support hooks. For example, by monitoring the three function code bits from the 68000, the MMU can divide the CPU's address space into user- and supervisor-level instruction and data areas. Thus, while you debug a program, the MMU can trap unauthorized (usually unintentional) attempts to access reserved system functions such as memory-mapped I/O or interrupt vectors. In this case, the MMU hardware ensures that a bug in a program does not hang the system.

Table 1: A *summary of memory management units.*

Device	Manufacturer	Translation	CPU Supported
68451	Motorola	Segmented	68008/00/10
68905	Signetics	Segmented/Paged	68000/10
68070	Signetics/Philips	Segmented/Paged	Integrated 68000
68910	Signetics	Demand paged	68010
68920	Signetics	Demand paged	68020
68461	Motorola	Demand paged	68010/20
68851/MMB	Motorola	Demand paged	68010/20
68851	Motorola	Demand paged	68010/20

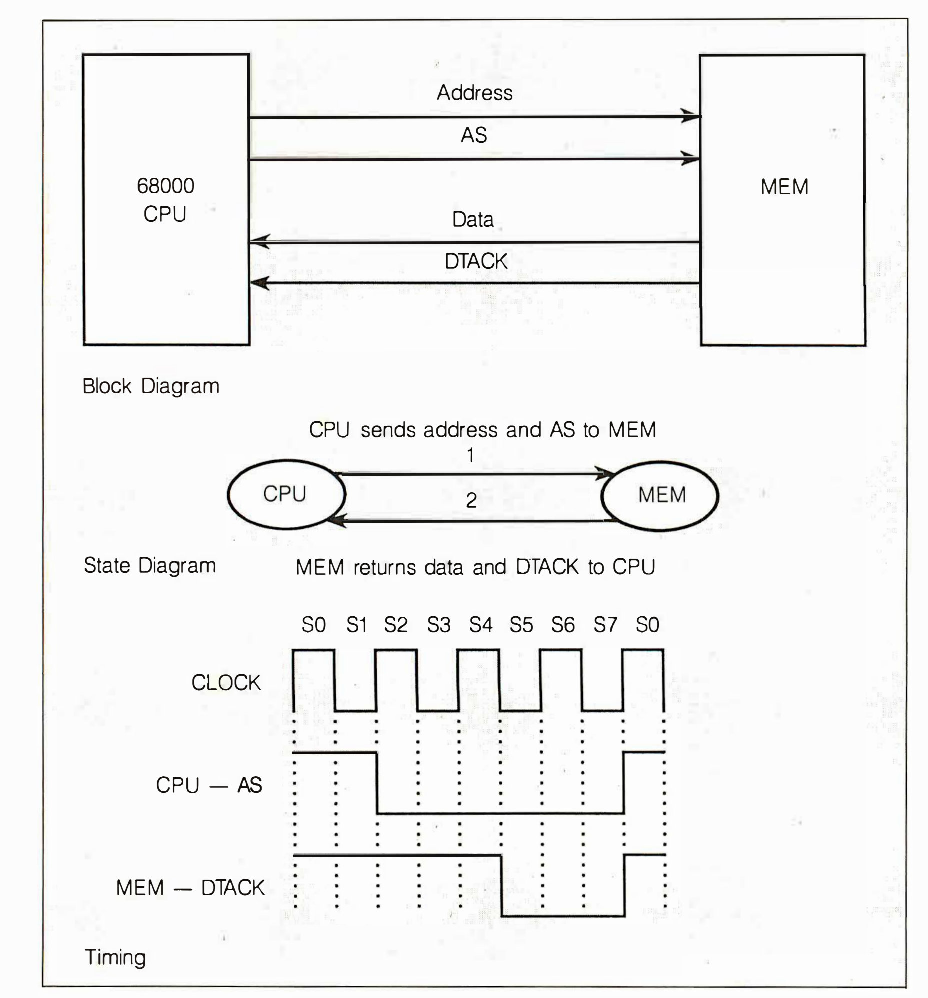


Figure 1: A 68000-*based system without an* MMU.

PAGED TRANSLATION

The translation rules that an MMU uses can be classified as being either paged or segmented. Paged systems usually divide memory into equal-size pieces (pages), while segmented systems divide memory into variable-size pieces (segments). Both of these concepts first appeared in mainframe and minicomputer systems.

In a paged translation (figure 3), the MMU divides the logical addresses into two parts; the upper bits are called the segment number and the lower bits are called the page index. The page index, which determines the page size, is passed directly through the MMU unmodified. The segment number is used as an address into a segment table. The data from the segment table is called the page address and forms the upper part of the physical address. Logically then, a memory location is described by a

13-bit offset into one of 2048 pages. Physically, memory is divided into 2K pages with a fixed size of 8K bytes.

Although several popular 68000/68010 systems have been built by simply implementing the segment table with high-speed static RAM, such an approach does not fit into 32-bit 68020 designs very well. If the lowest 12 lines are used for the page index, there are 20 lines left. This implies that the segment table RAM must hold 1 megabyte of page numbers.

Since pages have a fixed size, this type of translation is susceptible to internal memory fragmentation. This means that some segments will likely include memory that is unused. For example, suppose that a program needs 1K byte of storage for its data. When run, the system assigns the program one 4K-byte segment. The other 3K bytes become a memory fragment that cannot be used by any other program. Most paged systems include at least two levels of translation and a smaller page size that reduces such internal fragmentation.

A simple trick, however, can increase the capabilities of this approach. The segment table RAM can be wider than the segment number to provide additional control bits, and from the physical address bus, these control bits cannot be distinguished from normal 68000 control lines. So these extra bits can be used as address lines, and in fact this technique has worked to extend the addressing capability of CPUs ranging from the 6502 to the PDP-11. Other uses for these bits include memory protection attributes, virtual memory paging indicators, and cache inhibit mark bits.

SEGMENTED TRANSLATION

In theory, segmented translation should be more efficient since most memory requests are not integer multiples of some fixed-size page. The upper bits of the address are called the segment number and the lower bits are called the segment displacement or offset (figure 4). The segment number is used to address a table of descriptors. The descriptor includes a base address, which is the starting address of the segment in physical memory. The descriptor also includes the length of the segment. The segment offset should be smaller than the length; if it is not, the memory cycle is aborted and an error is indicated. Assuming there is no error, the translation is completed by arithmetically adding the segment offset to the base address. Physical memory can now be divided into 256 variable-size segments. Each segment can be from 1 to 64K bytes long.

Although variable segment size allows memory allocation to fit memory requests better, it leads to another problem called external fragmentation. This problem, which is unique to segmented MMUs, occurs when variable-size segments leave holes in physical memory that are too small for practical use. Several algorithms have been developed to simplify allocation in segmented systems and are described by Baer and Knowlton (see the Bibliography).

DEMAND-PAGED TRANSLATION

As CPU buses become wider, the amount of memory required to store page tables or segment descriptors becomes larger. This in turn increases the cost of the MMU and the overhead associated with task switching.

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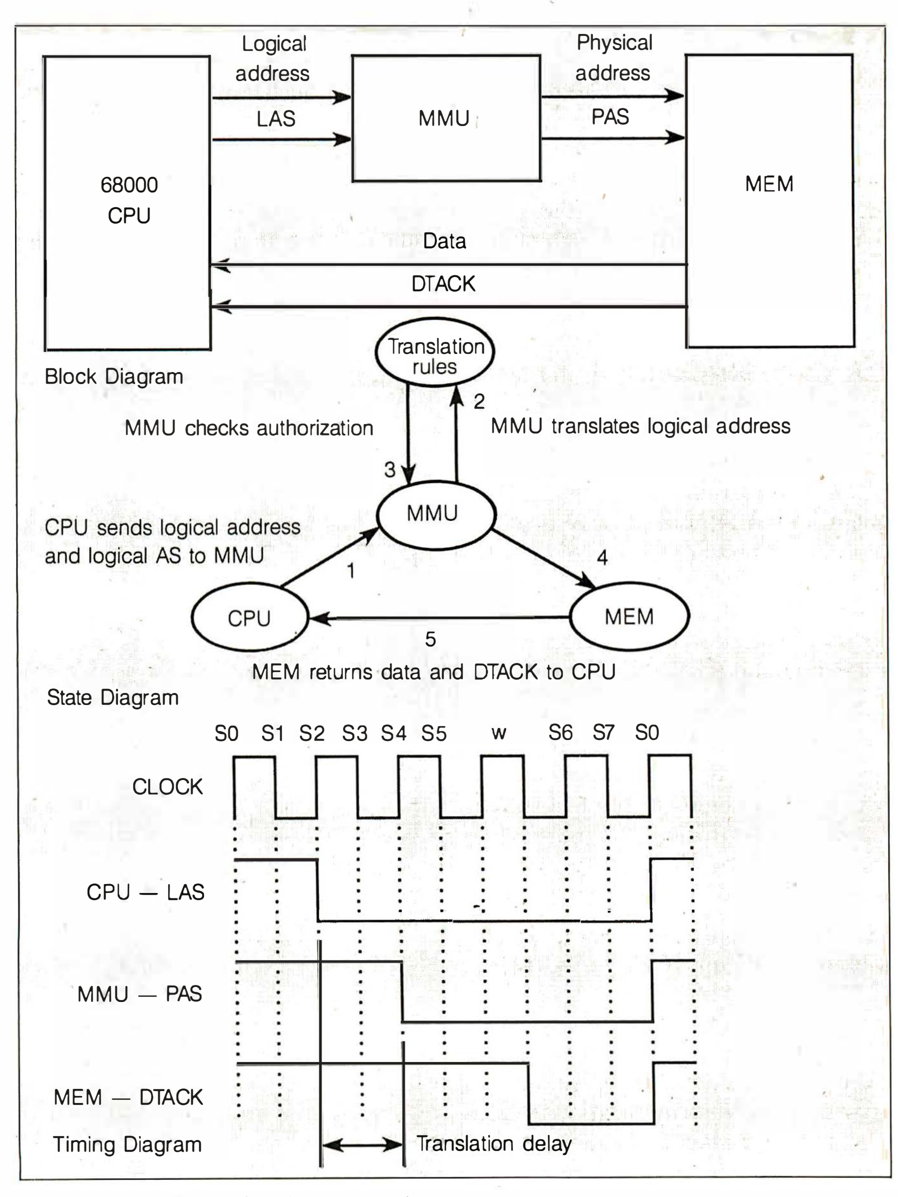


Figure 2: *A 68000-based system with an MMU.*

The demand-paged MMU provides support for 32-bit microprocessors by allowing translation tables to be stored in main memory (figure 5). When the system initializes, the CPU writes the translation tables into main memory and then tells the MMU where they are by writing a pointer into a control register. The MMU includes bus control logic that allows it to search the tables and find the correct translation information. To avoid searching the tables for each translation, the MMU maintains a buffer of recently used translation information in a small cache memory called a translation lookaside buffer (TLB). Thus, once the tables are established, the MMU can translate any logical address without advance warning from the CPU (translation on demand). This arrangement also means that the MMU will only take time to fetch those descriptors that are actually used by a program; in a timeshared, multiuser system this method is usually more efficient than loading all the descriptors each time the program runs.

When a demand-paged MMU finds the translation information in its TLB, it translates the logical address into a physical address. If the translation information is not in the TLB, the MMU must back the CPU off the bus while it searches the translation tables in the main memory. This search process is referred to as a table walk. At the end of its table walk, the MMU writes the new descriptor into its TLB and tells the CPU to retry the access.

Although the demand-paged MMU provides an elegant solution to a difficult problem, the table walk process is slow. A typical table walk will cost the CPU 20 or more wait states. This means that the performance of the MMU is governed by the percentage of times that it finds the needed information in the TLB—the TLB hit rate. If the CPU includes an efficient cache memory, the TLB hit rate may very

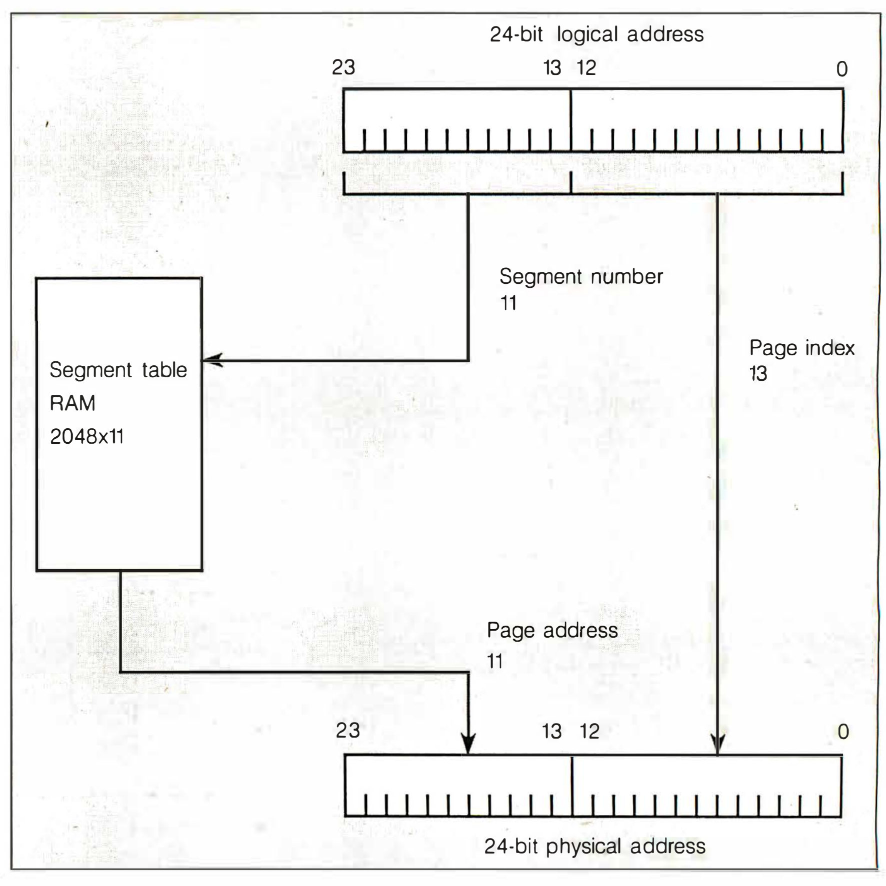


Figure 3: *In a paged translation the upper bits are called the segment number and the lower bits are called the page index.*

well become the factor that limits system performance.

If you plan to include an MMU in your next design, you must match the CPU and MMU combination with the overall system architecture and cost. For each possible MMU design alternative you must consider hardware and software issues. The most important hardware issues include how to minimize translation delay, how the MMU should signal error conditions to the CPU, and how to reduce hardware overhead related to a software task. Of course, the nature of these issues depend on whether you are using a 68000, 68010, or 68020.

In typical systems, a discrete paged MMU will support a simple operating system or real-time executive in a small single-user or embedded control system. Segmented systems have been used in large computers for many years, but the advantages are probably not worth the additional complexity in a small system. The demand-paged memory system provides the best features of both paged and segmented systems and has become the standard for multiuser UNIX machines.

MMU Design Options

Given an understanding of the MMU's theory of operation and the system design considerations, there remain the actual design implementation options. The first and most obvious option is to not use an MMU at all. That's exactly the design decision made for the Apple Macintosh, the Commodore Amiga, and the Atari 520ST. Although the graphics interface used by these machines, which includes multiple windows and desk accessories, may give the impression the systems perform multitasking quite naturally, none of these systems includes any MMU hardware. Instead, they place the burden of memory management on application software. In each case

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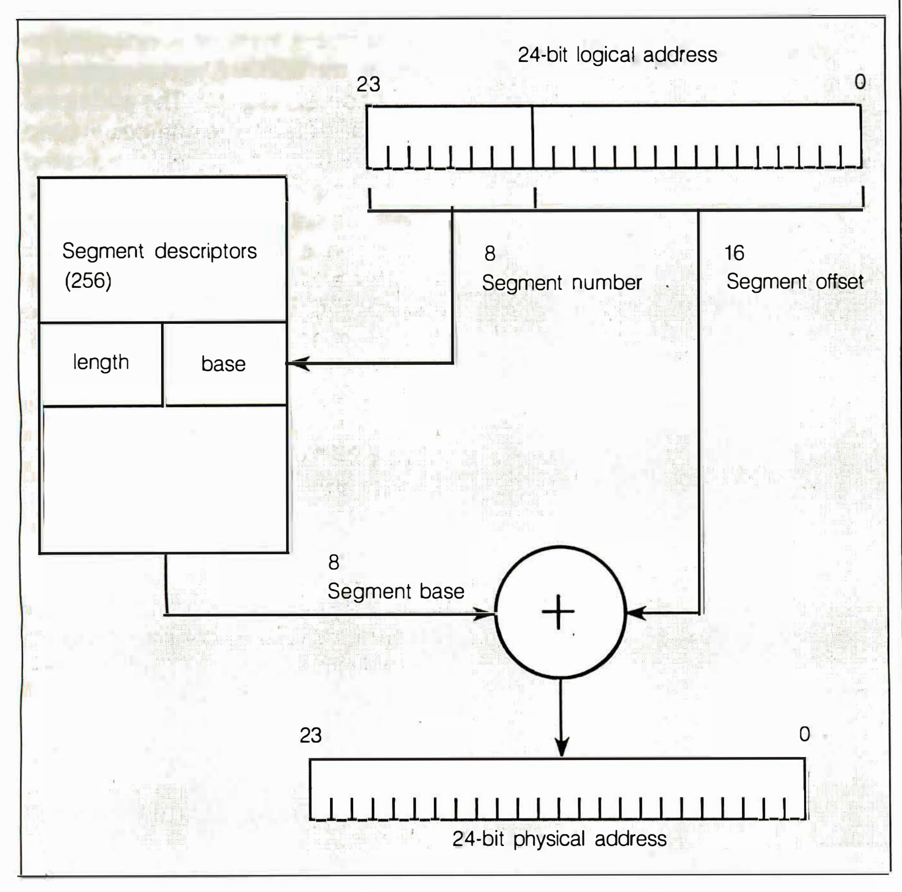


Figure 4: *In a segmented translation the upper bits are called the segment number and the lower bits are called the segment displacement or offset.*

the designers have provided a real-time executive with a set of low-level interface routines and a complex set of so-called gentlemen's agreements to provide multitasking. For example, an application running on one of these machines must understand when and how to call low-level routines for tasks such as memory allocation. It is also up to the application to decide what to do if those routines cannot allocate the requested memory.

Figure 5: *Demand-paged translation state diagram.*

Figure 6: *Two-level paged translation.*

Also, when a program runs on one of these machines, it has access to all system resources, and a programming error can easily write over any of the other programs in memory including the operating system. This is usually a fatal situation to the system, requiring a power reset. Even a modest amount of MMU hardware could improve the performance and reliability of these machines by reducing the amount of memory management the operating system has to perform and by providing memory protection in hardware.

A paged MMU can also be built using discrete logic and high-speed static RAM to hold the segment table. This approach was very common in early 68000-based multiuser systems. The basic paged-translation concept is usually extended to two levels (figure 6). In this approach, the logical address is divided into three fields. The segment number is extended to include the 68000 function code bits and a context register. The additional field, called the page number, is used to address the page table indicated by the segment table output. Most operating systems set up the segment tables once, then use the context register and page tables to allocate memory for each task. The page tables are small enough that they can be paged to main memory when a task switch occurs.

The 68451 MMU

Shortly after the first 68000 CPU chip made its debut, the Motorola 68451 appeared. It was, in fact, one of the first monolithic MMUs available to system designers. The 68451 is a segmented MMU that comes packaged as a 64-pin DIP (figure 7). It includes 32 segment descriptors that partition memory into variable-size segments. Each of these descriptors also includes an 8-bit status register that provides support for a virtual memory architecture.

There are several serious limitations with this device, however. The biggest problem is that 32 descriptors are not enough. The 68451 includes special

lines that allow several chips to be chained together to expand the number of descriptors, but since the MMU still costs almost twice as much as the CPU, this is an expensive option. The 68451 is also relatively slow. Typically, translation requires more than one wait state (especially in a multi-MMU system), and if a task switch requires CPU intervention (and most do), the overhead is greater than that of a simple paged system. The 68451 also lacks support for CPU cache memory or the 32-bit 68020. Since all of these problems have been resolved with a new Motorola MMU chip, the 68851, the 68451 will probably not be used in many new designs.

If you are porting an operating system to a machine that does use this device, you should consider using the binary buddy memory allocation algorithm as described by Knowlton. This algorithm should allow you to take advantage of the variable segment size while reducing fragmentation and operating system memory allocation overhead.

THE 68905 BMAC

The 68905 basic memory access controller (BMAC) is the first in a series of ambitious announcements by Signetics and its parent company, Philips. The BMAC integrates MMU and cache control functions for

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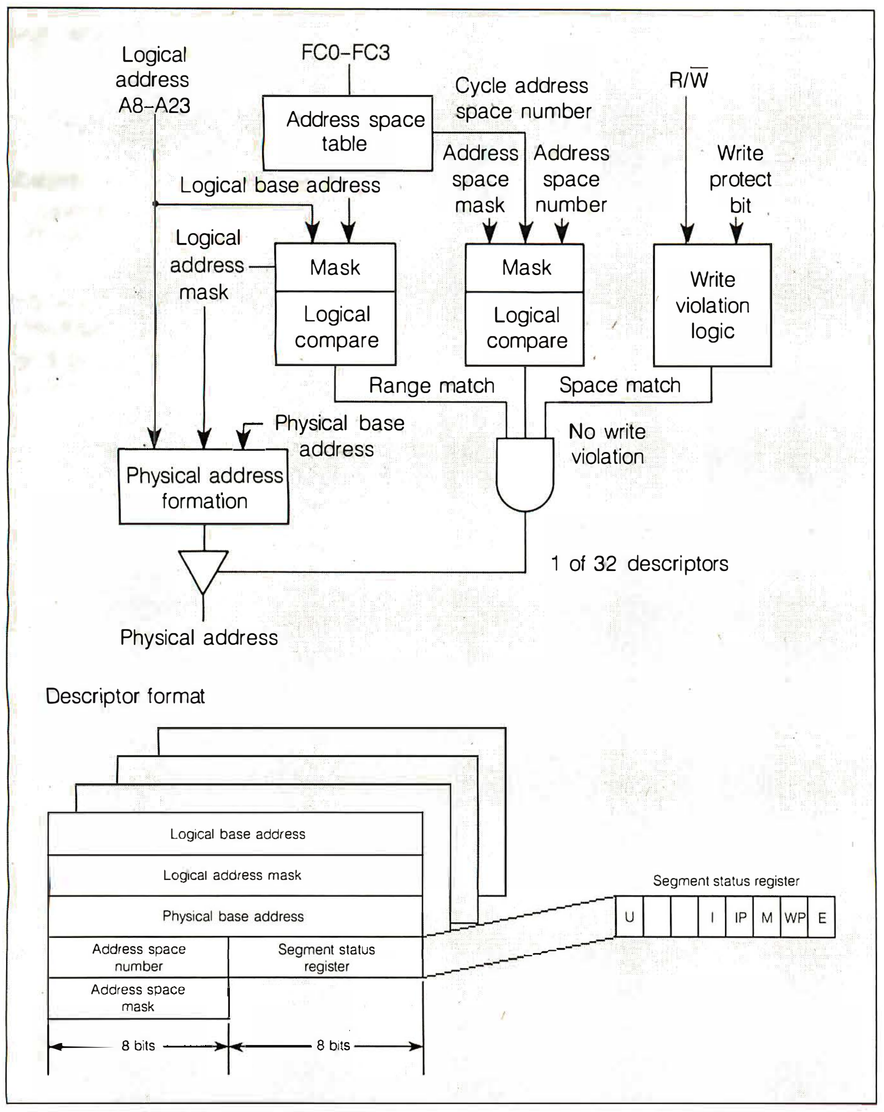


Figure 7: 68451 MMU.

68000/68010-based systems into a single 84-pin grid array package (figure 8). You can program the BMAC to perform segmented or paged translation.

Most MMUs that support paging data between hierarchies of memory allow two levels that are usually dedicated to primary memory (RAM) and secondary memory (disk). The BMAC also supports a third level, local memory (RAM). Although most operating systems do not currently support this third level, local memory could be used to provide improved performance in a multiprocessor system. Using this local memory would provide fast access to private data structures.

The BMAC also provides support for a logical bus cache memory. Placing the cache on the logical bus allows translation and cache searches to occur in parallel, but in order to avoid cache coherency problems, care should always be taken to flush the cache at each task switch. Although a logical cache is fast, it may not, however, be transparent to the operating system.

Signetics has also announced the 68910 and 68920 memory access controllers, or MACs, that extend the BMAC design by including a micro-controller that effectively provides demand-paging capability for 68010 and 68020 systems.

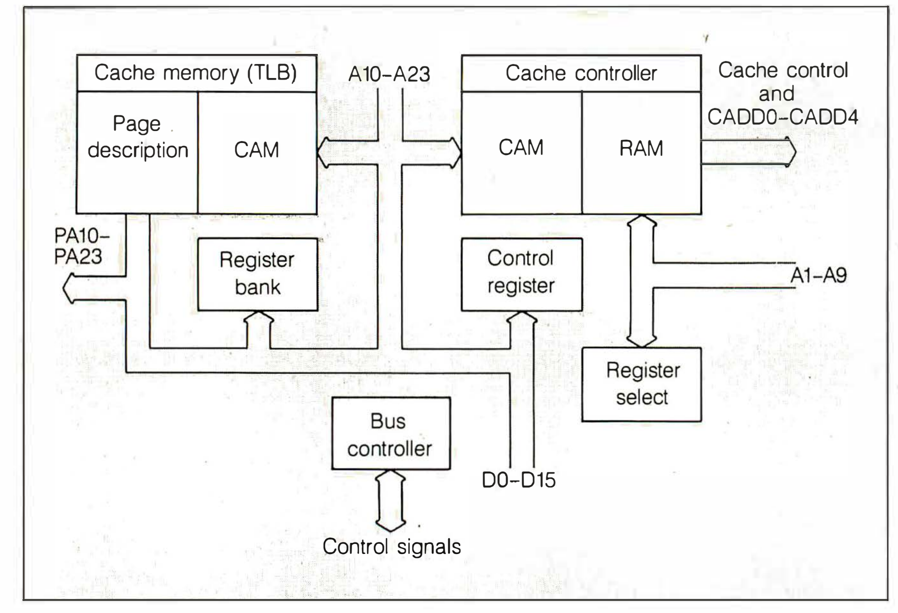


Figure 8: 68905 *block diagram.*

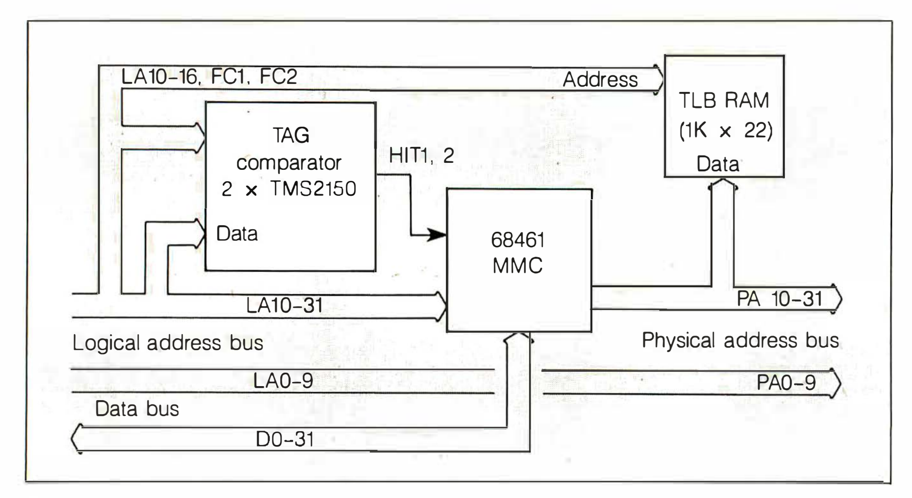


Figure 9: *Block diagram of* MMU *using* 68461.

THE 68461 MMC

Shortly after introducing the 32-bit 68020 CPU chip, Motorola announced its plans to develop a demand-paged virtual MMU, which would support multitasking, multiuser environments such as UNIX. Unfortunately, the new MMU chip was not ready in time to be shipped with the first CPUs. Recognizing the need for MMU support, Motorola made the 68461 memory management controller (MMC) available as an interim solution—until the single-chip 68851 paged MMU is available.

The 68461 is fast; it's built with Motorola's 2800-series bipolar gate array, and it can translate a 16-MHz 68020 access in one wait state. The MMC is housed in a 147-pin grid array package, which requires a heat sink. The MMC does not include everything required to implement a demand-paged MMU. To use this device, you must use external logic to implement the TLB function. A single-set-associative TLB can be built with 15 or 16 external chips (figure 9). Even this simple TLB architecture, however, offers a hit rate in the UNIX environment of better than 90 percent, which is high enough to provide good system throughput.

An MMU incorporating the MMC can provide demand-paged memory support for either the 68010 or the 68020. It includes the extra control bits that are required for memory protection, virtual memory, and CPU cache memory functions. It maintains its translation descriptors in a tree structure in main memory. The translation process divides the logical address into three fields, which are used to search three levels of descriptors (figure 10). Limit fields at each level of the table reduces the total amount of RAM needed to hold the descriptors. Yet a typical system requires about 128K bytes for the MMU. Protection bits at each level of the table can provide read and write access protection based on the function codes. For example, you can configure a page to allow supervisor read

and write access while a user mode write will generate an error.

THE 68851 PMMU

The Motorola 68851 paged MMU, or PMMU, provides complete demand-paged MMU support in a single chip. This advanced design includes a 64-entry fully associative TLB that is more efficient than the single-set design of the 68461 MMC. Since the PMMU attaches to the 68020's coprocessor interface, its registers are extensions to the existing programmer's model of the CPU. The CPU/PMMU combination adds new MMU instructions to the existing 68020 instruction set. While all the other devices discussed here decode the MMU's control registers as memory-mapped I/O, this coprocessor approach integrates the PMMU into the programming environment. For example, a single instruction allows a conditional branch based on the condition of the PMMU status register.

The PMMU's translation mechanism is similar to the MMC, but the PMMU offers more flexibility. The PMMU page sizes can range from 256 to 32K bytes, and page tables are not fixed at three levels. The PMMU can partition the logical address into one to four fields, each of which serves as an index to the table at that level.

PMMU hardware includes arbitration logic for both the logical and the physical bus. A separate pointer register is provided for an alternate logical bus master, such as a DMA controller. In a multiprocessor environment, PMMU's can share descriptor tables in main memory, reducing storage requirements. The PMMU offers full support for system functions such as virtual memory, cache memory, and a floating-point coprocessor.

Besides using the CPU function code bits for memory protection, the PMMU adds up to eight levels of access authorization. This concept is also extended into the 68020 call module (CALLM) and return from module (RTM) instructions so that authorization can be verified at the subroutine level.

For the faint of heart, Motorola also offers the 68461 and discrete TLB already assembled on a printed circuit board, which is pin-for-pin compatible with the 68851. You can plug this board-level product, the 68KVMMB851, into your next 68020 design to provide MMU support until the 68851 is available in production quantities.

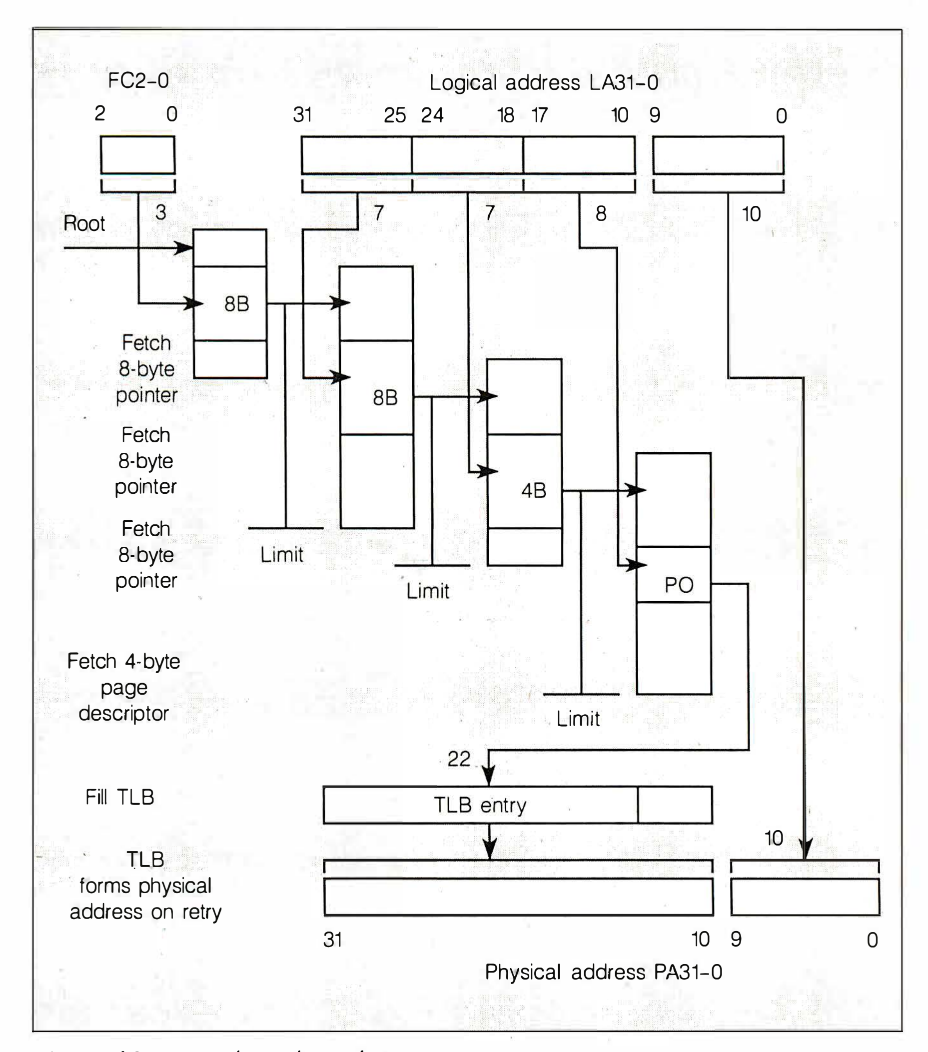


Figure 10: *Demand-paged translation.*

FUTURE TRENDS

It's difficult to determine which has advanced more rapidly, the microprocessor or the MMU. Certainly the supermicrocomputers available today depend on the MMU just as much as the microprocessor to provide high performance for a lower-than-ever cost per user. If history is any indication, IC manufacturers will continue to integrate more and more system functions onto silicon.

Integrated units that combine the 68000 CPU and a simplified 68920 MMU in a single device, such as the recently announced Signetics/Philips 68070, are sure to abound in the future. The advantages of putting the CPU and MMU on the same silicon include faster translation, lower pin count (and therefore cost), and improved software portability. Moreover, by offering silicon that can simplify the layer of software required for multitasking, this device is sure to find its way into the next generation of mouse-and-windows machines. ■

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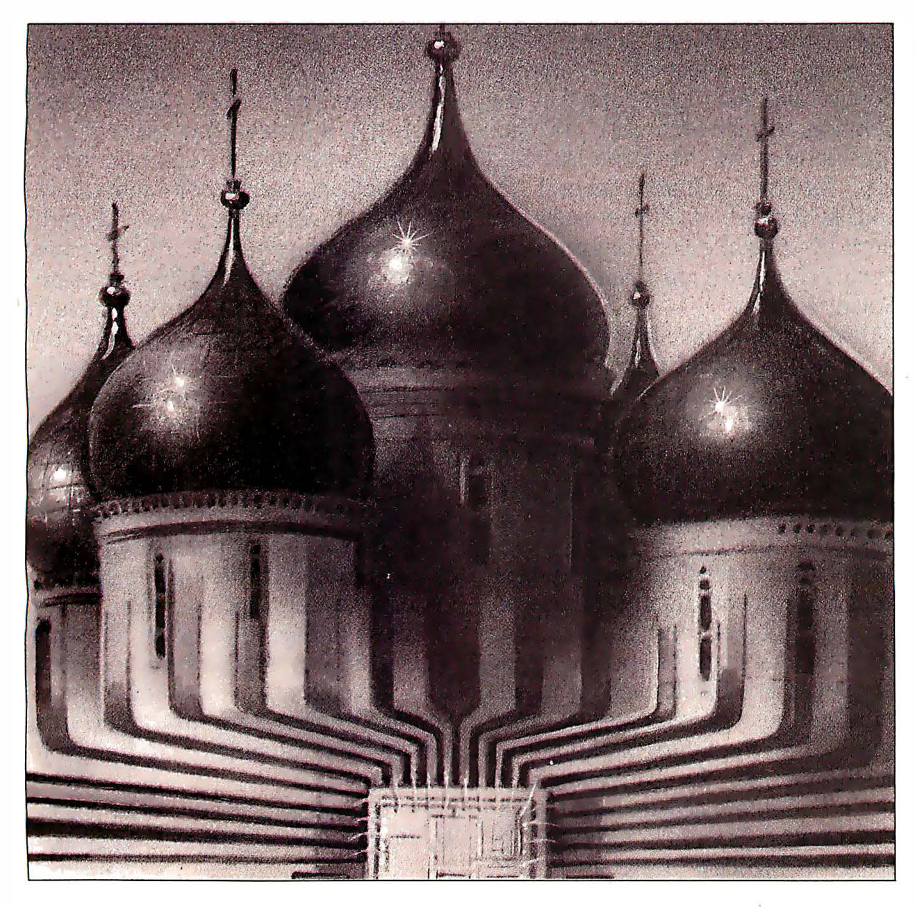
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BY PAUL WALTON

THE STATE OF SOVIET MICROELECTRONICS

Is the Soviet Union doomed to lag behind the West?

When microelectronic technology and personal computers first appeared in the West 15 years ago, the Soviet Union was building the versions of third-generation IBM mainframe computers on which it still relies. While the East Bloc covertly acquired minicomputers for reverse engineering, IBM overtook Apple in the personal computer market, and the first 32-bit microprocessors put the power of a minicomputer on a single chip. But only now are microcomputers becoming available to the children of those party members allowed to buy them.



To say the least, the Soviet computer culture is weak. Original and copied IBM PCs and Apple IIs are reserved for the state, military, and party elite. Packaged software is scarce, printers are poor, disk drives are rare, modems are virtually unobtainable, and there is no public digital data communication network.

Enthusiasm for personal computers is muted because East European copies of Western computers are unpredictable, inefficient, and garish in design, with their heavy gray or black metal cases, bright emerald-green phosphor screens, and sticky, unresponsive keyboards. The few office systems in the U.S.S.R. are based on CP/M and MS-DOS operating systems. Popular applications packages from the West such as WordStar and VisiCalc are available, but not with Cyrillic scripts.

In fact, the Soviet Union seriously lags behind and greatly relies on the West, according to Professor Seymour E. Goodman at the University of Arizona's Department of Management Information Systems (see refer-

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ILLUSTRATED BY TOM CENTOLA

The Soviets recognize the need for small systems, but so far have failed to match Western technology.

ence 1). In effect, he argues, the Soviets go about things in entirely the wrong way. They decided to follow the West, ditching almost all indigenous developments in favor of copying—to the extent that they are sentenced to lag several years behind.

Goodman is roundly skeptical of the East Bloc's capabilities, yet other observers are more optimistic. A British study of Soviet microelectronics to 1982 states that the West has underestimated or even ignored Soviet accomplishments (see reference 2). Paul Snell from Birmingham University's Centre for Russian and East European Studies says that copying can bring rewards. Pentagon research on covert Soviet acquisition supports Snell's arguments. According to one study, the Soviets saved billions of dollars on military development costs by obtaining thousands of items for subsequent copying. As a result, their microelectronics industry made significant advances, which "reduced the overall Western lead . . . from 10 to 12 years in the mid-1970s to 4 to 6 years today" (see reference 3).

DEVELOPING A NEW INDUSTRY

The Soviet electronics and computer industry is highly diffuse, controlled by the defense-oriented Military-Industrial Commission (VPK) and spread across several ministries. The State Committee for Science and Technology acts as the domestic policy-making body for a large domestic manufacturer and a few smaller subsidiaries, while the Council for Mutual Economic Assistance (CMEA), a body designed to ensure the socialist division of labor, coordinates Warsaw Pact activities on research, standards, and production levels.

In practice each CMEA member country is charged with producing a different component part or microcomputer peripheral, and in each country a separate organization or factory might further subdivide production. Managing this system without access to computers is a nightmare. Parts are often mismatched, testing is poor, and software and systems are often left to the unfortunate end user to sort out.

This organization coped well enough with the supply of mainframe and minicomputers, copying IBM and DEC hardware and software, with satellite states manufacturing peripherals such as disk drives, printers, and terminals. But it failed to track innovations in microcomputers until the late 1970s. The Soviets then recognized the need for small systems, but so far have failed to match Western technology.

There has been no competitive customer demand, entrepreneurial spirit, or free exchange of ideas to match Silicon Valley. For instance, the output of the main VPK-run factory, which produces microelectronics, minicomputers, and microcomputers in the Zelenograd high-tech park 30 miles outside Moscow, has been reserved first for the military, second for GRU/KGB state security services, and third by special edict from the Politburo. Zelenograd has been closed to Soviet citizens.

Development has also been stifled by technological shortcomings. Small systems began as a development of minicomputer technology in the U.S.S.R., aping the development of PDP systems and later LSI board-level systems. Bit-sliced processor design was taken up, but the gains of LSI microcircuits could not then be realized. Sophisticated software was assiduously copied. But basic innovations such as simplified programming languages like BASIC were ignored.

Indigenous developments were quashed by the Soviet computer industry, despite the capabilities exhibited. (Centers of excellence exist: The Central Scientific Research Institute in Moscow designed 8- and 16-bit mini- and microcomputers, and the National Cybernetic Institute in the Ukraine developed a microcomputer DOS, which was dropped in favor of CP/M.) Copying was preferable because it was thought to be more reliable. It was perhaps essential when the Soviet authorities dictated that space and nuclear weapons programs must keep up with Western technology, which was growing many times faster. The bureaucratic party attitude became "West is best; East is least."

The party even declared a second space race, this time in computers. President of the Moscow Academy of Sciences and chief Soviet scientist Alexi Alexandrov said that despite the technology gap, and in the face of a technology embargo, the U.S.S.R. would go all out to catch up: "Have [the Americans] forgotten that problems of no less complexity, such as the creation of the atomic bomb or space rocket technology, . . . [we] were able to solve ourselves without any help from abroad, and in a short time" (see reference 4). Brave words, but the reality is a little different.

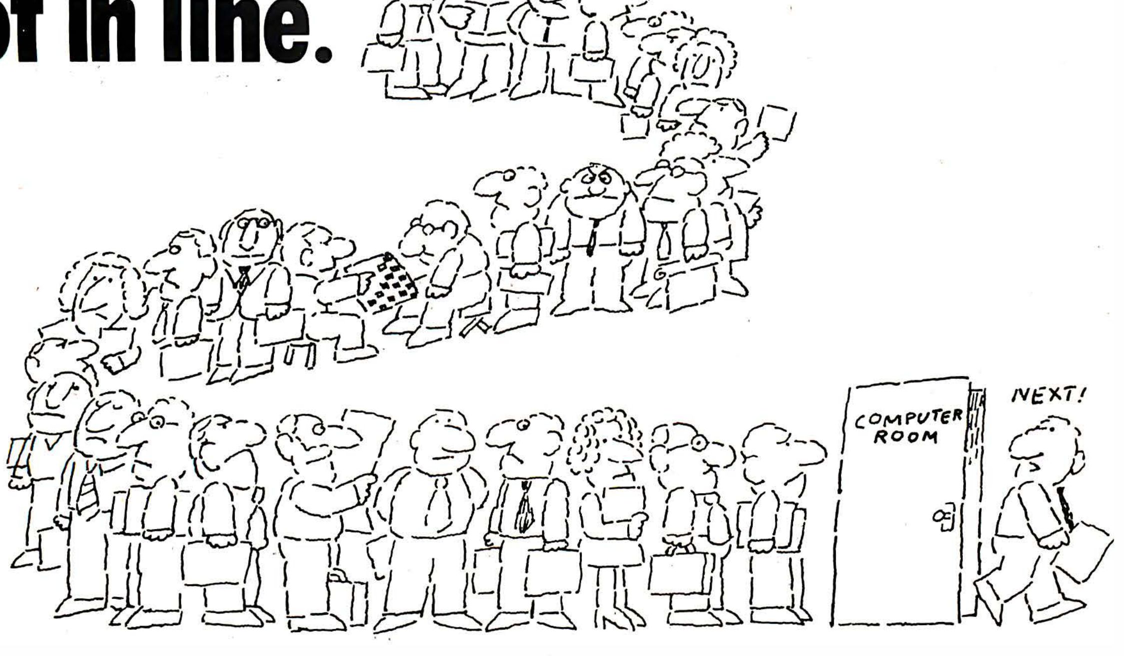
According to Snell, an air of confidence returned to the Soviet computer industry in 1979. He even suggests that the industry could now progress independently. Microelectronics production has been mastered, thanks to an infusion of Western manufacturing equipment prior to the tough embargo introduced by President Ronald Reagan. In fact, direct copies now make up only part of the Soviet microelectronics inventory, and Snell adds that there are signs of ingenuity in the designs of the microelectronic devices he has studied.

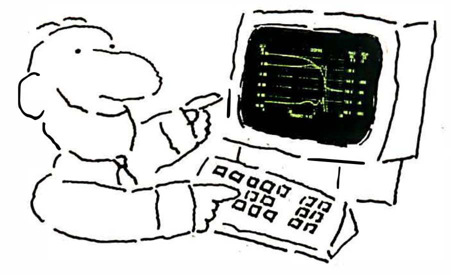
The East Bloc is not standing still; the Soviet Union has established a commission to consider ways in which it can overstep the present technology gap and move directly from third- to fifth-generation technology. And CMEA is organizing a research and development program for the socialist member countries, and it is improving the standard of production facilities.

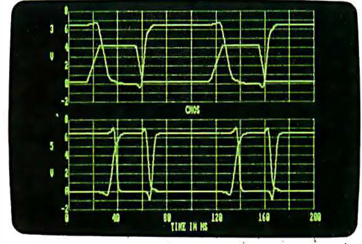
Hungary has unveiled its own ambitious project to develop VLSI cir-

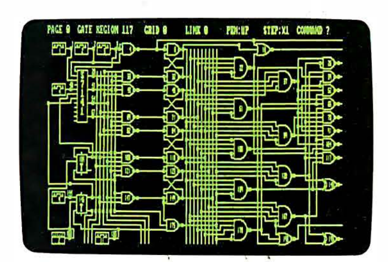
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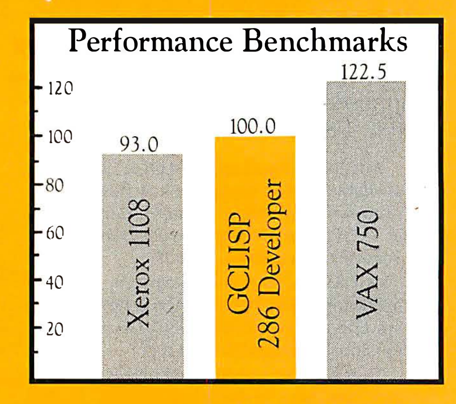
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cuits. It has developed a local microcomputer industry around the state-owned manufacturer Videoton and small software houses. And Hungary now has the capability to produce artificial intelligence systems using the Prolog language.

Poland was similar to Hungary before the present civil and economic clampdown. Small-scale enterprises were developing software and microcomputer-based systems for sale in and out of the East Bloc. Advanced fourth-generation software, especially in the field of database management, is a notable Polish achievement.

East Germany's state-owned Robotron is producing an office system and general computer line that matches Western suppliers like Wang or IBM, and the country has turned the precision camera-maker Zeiss to making display units and optical drives. East Germany is the largest East Bloc supplier.

Czechoslovakia, like East Germany, has the task of mass-producing a full range of microelectronic devices. That country's automated factories and skilled workforce tend to produce more reliable products than the U.S.S.R. Together, Czechoslovakia and East Germany are expected to produce 2 million ICs annually.

Bulgaria produces traditional magnetic storage media, including tape and disk drives, at the Beroe plant on the Black Sea. This plant also refined basic microelectronic production techniques to produce RAM chips.

Yugoslavia has historically had a strong telephone industry, and the semiprivate Iskra Associated Enterprise (IAE) has the job of producing advanced telecommunications products—digital switching, modems and multiplexers, and laser and satellite links. IAE also trades with the West, exporting $106 million in 1984.

MANUFACTURING LIMITATIONS

Manufacturing is generally the big headache for all these countries—Soviet production techniques are way behind those in the West. (Czechoslovakia is more advanced in the production of some microprocessors, East Germany in making memory devices.) Manufacturing problems are exacerbated by the logistics of reverse engineering, or the process by which copies are made of basic components. Goodman says, for example, that miniaturization of microelectronic circuits has made it more difficult to interpret the original design of microprocessors that cannot be bought directly by the U.S.S.R.

To make matters worse, Soviet scientists do not have the benefit of CAD/CAM. They cannot define a circuit by minimizing the distance between internal connections, so Soviet chips tend to locate similar functions together, regardless of the resultant inefficiency. Together with the aggravation in covertly obtaining all the component parts or information, even for a single device, the overwhelming efforts involved in reverse engineering do not yield comparable rewards.

The Soviets have generally shied away from the highest technologies such as LSI and VLSI, and sophisticated fabrication techniques such as that for CMOS (with the exception of a military-led initiative to develop GaAs production in space). A few VLSI devices, such as the K1801VE1 16-bit single-chip microprocessor, do exist, but they are the exception.

Instead the Soviets have concentrated on traditional design, fabrication, and packaging of traditional devices, such as bit-sliced microprocessors. This has meant that small systems are limited to the speed, capacity, and functionality of the very first microcomputers. (The Apple II-compatible Agatha, named after a favorite niece of Brezhnev, is perhaps an apt example of leading-edge Soviet products.)

Paradoxically, Soviet-designed 8-/16-bit, 16-bit, and 32-bit microprocessors exist. But these are short-run devices intended primarily for the military, for nuclear or space research, and for use in prestige factory automation and robotics projects. Mass-market microcomputers take a back seat.

The staple diet of homemade devices is supplemented with other copied devices including the Zilog Z80, Intel 8080, 8086, and 8088, and Motorola's 64K-byte static and dynamic RAM—all known to be in large-scale (several thousands) production in at least three Warsaw Pact countries.

The staple diet of homemade devices is supplemented with other copied devices.

TECHNOLOGY EMBARGO

The Pentagon has successfully lobbied for tight export controls to restrict the trade in basic manufacturing capability. The argument is that U.S. products and know-how go into Soviet weapons systems, giving them an edge and saving R&D expenditure. One section of a report (reference 3) on the covert acquisition of computers and microelectronics fabrication equipment suggests that "nearly half" of the covert trade diversions fall into this category.

A catalogue of equipment obtained in one year during the early 1970s includes 30 sophisticated crystal pullers, 99 diffusion furnaces, 3 integrated circuit testers, and 10 mask aligners. The list for the following year includes 24 crystal pullers, 64 diffusion furnaces, 3 photorepeaters, 3 pattern generators, 3 epitaxial reactors, and an IC tester. Raw materials, too, are required by the U.S.S.R. By 1980—before export controls—the Soviets had purchased hundreds of tons of electronics-grade silicon.

The report alleges that integrated circuits are also obtained in great quantity—as many as 100 million circuits a year. Suppliers face stiff penalties under the U.S. Export Administration Act, but the trade still continues.

Export law (defined under the CoCom rulings and translated into law by each of the Western allies and Japan) allows certain small systems to be exported but denies others that are more powerful. It is illegal to export the IBM PC, for instance, but not the Commodore 64. A simple, single-user accounting package can be sold across the Iron Curtain, but not the

(continued)

multiuser version. And while a monochrome monitor is okay, a high-resolution color monitor is not.

Ambiguity in these laws, their complexity, and the lure of greater profits have conspired to produce "gray" exports to the Warsaw Pact. BK Dynamics estimates the value of hardware alone to be in the billions of dollars. In Europe and Japan many traders simply ignore export laws.

The trade in other component parts—drives or expansion boards, complete small systems, systems software and applications—is probably impossible to quantify given the ease with which products can be obtained. One U.S. export official in London says that this illegal trade is "a mist floating Eastwards: How can we grab mist?"

Another by-product of the embargo has been increased Soviet efforts to coordinate computer research and development, improve manufacturing, and rely less on imports. Snell points out that *Pravda* (July 10, 1984) even says the Soviet Union benefited from the trade sanctions.

SOVIET OUTLOOK

To date, the Soviet Union has developed 15 distinct microprocessor

Table 1: *The Soviet microcomputers.*

Model	Processor	Bits	DOS and Programs	Major Uses
Elektronika-60	K581/K536	16	BASIC FORTRAN Assembler	Word processing, data storage, and accounting (a wide range of peripherals such as printers and extra terminals is available)
Elektronika-S5	K536	16	Assumed to have ported MS-DOS (2.0 or higher), MBASIC, etc., on to later machines such as S5-21	Multiboard and single-board microcontrollers, and single-chip, 16-bit microprocessors
Elektronika-NT	K587 or K1801VE1	16	MS-DOS 2.0 or higher Now porting CP/M-86	Largest selling micro for business use in USSR; designed at the Central Scientific Research Institute (TsNII)
Kristall-60	K80IK80	8	Intel 8080A look-alike chip running CP/M	Large seller, educational version available to schools
Agatha (or Agat)	K587	8	Supposedly running Apple ProDOS under a copy of the 6502 instruction set	Apple II copy, packaged in a single unit; small production run only; difficult to obtain Apple peripherals, software, add-ons, etc; popular with scientists and programmers.
Iskra	580 series chips	16	Direct copy of IBM PC; runs English PC-DOS, GW-BASIC, MicroCOBOL, and POP software packages (Cyrillic DOS being developed)	Very few Russian PCs have been made; copies are significantly slower, have poor (mono only) display, and consist of 5 system components (rather than 3); hard disk to 5 megabytes only; few peripherals and little or no add-ons

devices, including direct copies like the K580 (Intel 8080A), K589 (Intel 3000), and K1804 (Advanced Micro Devices 2900). The KR580IK80A microprocessor is a modified version of the Intel 8080A that even bears the U.S. part number (note the "8080A" in KR580IK80A). But the Pentagon report confirms that copying is getting more difficult, and so reverse engineering is expected to be less frequent in the future.

From the basic Soviet components, at least four major small system computers have been produced (table 1). These small systems are based on implementations of either CP/M or MS-DOS. These small systems conform to Western operation but are lacking in functionality and speed. Although most are obtained only through work organizations, party members and local officials can buy home computers priced from around 300 rubles (about $225), but that price might represent three months' pay. Western machines are not available—even in the elite Moscow party shops such as GUM.

The Kristall-60 (presumed to be the biggest seller) and other 8-bit micros with ancient versions of CP/M are just now reaching the mass market. Some Moscow schools are even getting educational versions of the Kristall. The Agatha is particularly popular with programmers and scientists, but it is in short supply.

True 16-bit micros are rare in the Soviet Union. The IBM PC–compatible Iskra is reserved for the important state bodies, local party dignitaries, and the GRU/KGB. But the Electronika NT line of MS-DOS 2.0–based computers has been taken into mass production. In fact, one model has sold several tens of thousands.

But the lack of good software has created a major problem. The Soviets do not tend to produce Cyrillic-based operating systems, compilers, and programming languages. A drive to collect indigenous programs, to commission basic packages, and to convert more Western software is now being promoted by the old Algorithm Committee at the Moscow Academy of Sciences. (Many Western firms report that customer support and service notes and inquiries about software often find their way from the Soviet Union, even though no record of a sale can be found.)

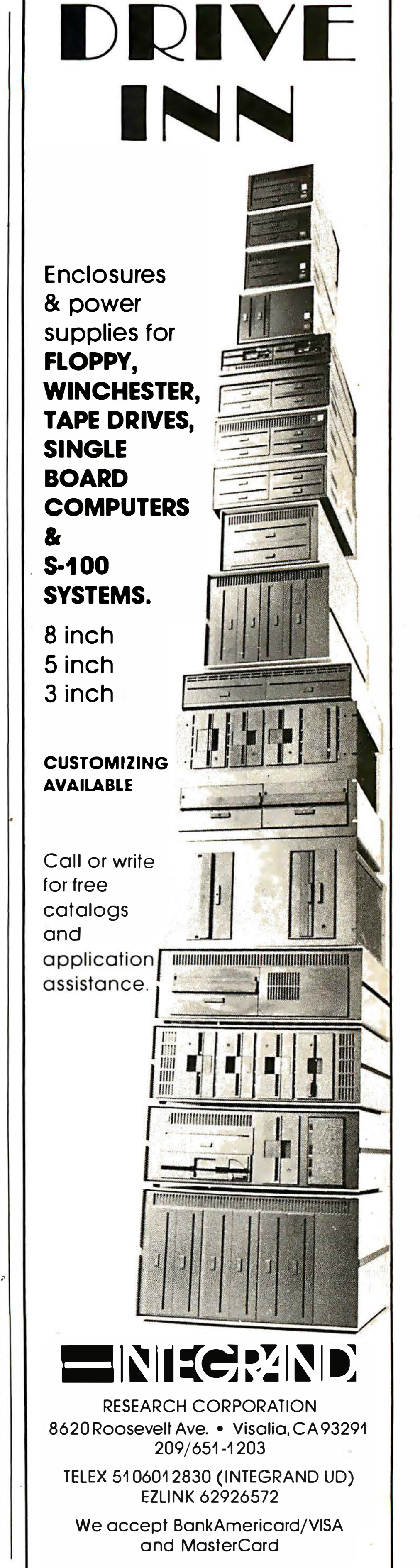
The solution to this software problem involves the mass availability of systems and a higher level of computer literacy than currently exists. Although numerous training schemes have been considered, little has been done to provide more machines. A microcomputer education course by mail, for example, instructs students in DOS and BASIC commands—but without the luxury of a computer. And the story in schools and colleges is the same.

Peripheral devices such as second floppy disk drives, hard disks, daisy-wheel printers, and graphics output devices are even more difficult to obtain. Expansion boards are rare. Magnetic media are expensive. And to be caught with a modem or acoustic coupler would be viewed as a reprehensible civil offense by the KGB. The State is paranoid about the free flow of information.

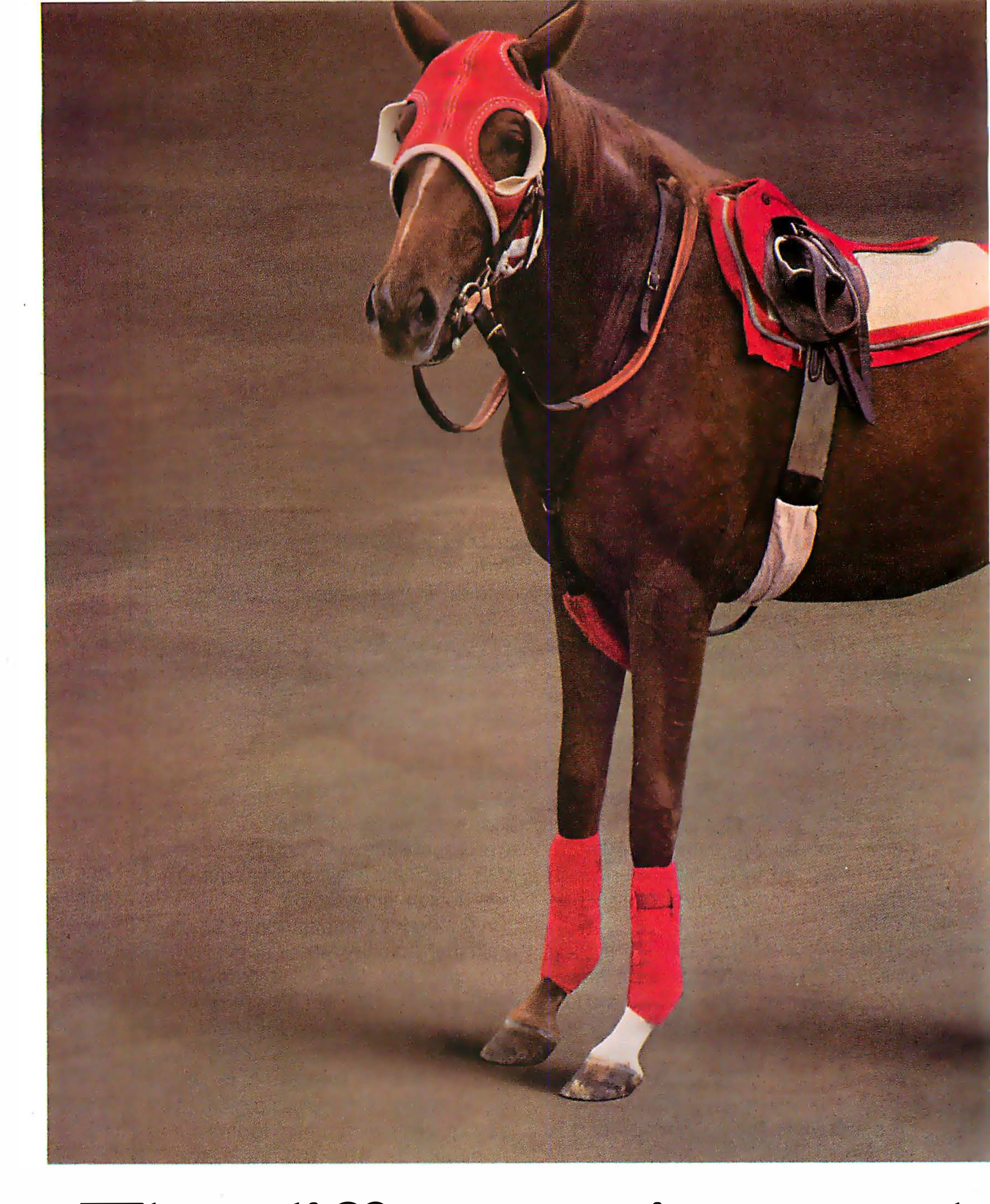
In the end, a combination of Soviet technical inability, strict administration, and the lack of a computer culture will inhibit the growth of this industry. And because of this, the efficiency of Soviet administration and economy and the freedom of its people will suffer. On technology alone, the Soviets may appear doomed to lag behind the West. But that view of the Soviet microelectronics and small-system industry may soon change. Soviet premier Mikhail Gorbachev has addressed every major political meeting and organization to the problem of technological rebirth. ■

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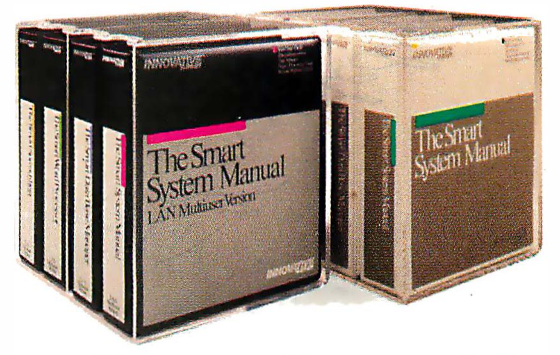
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Inquiry 159

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Representing Knowledge

REPRESENTING KNOWLEDGE, some researchers say, is the key issue right now in the development of artificial intelligence. There's no doubt that progress in recent years has been impressive, especially in commercial knowledge-based or expert systems. But AI researchers still struggle with the problems of encoding massive amounts of information and formal reasoning procedures as data structures that computers can manipulate with ease.

This month's theme presents new approaches to the problems of representing knowledge. In the articles that follow, the programming techniques vary. Most rely on general-purpose programming languages like Pascal and BASIC, a couple make use of Prolog, and one is based on a specialized AI language. The types of knowledge-based systems vary as well, reflecting the thought that the merits of a particular scheme depend on the eventual use of the knowledge.

Leading off, Beverly and William Thompson examine a technique based on the ID3 algorithm, an induction method often used for building commercial expert systems. Implemented here in Pascal, the algorithm reduces redundancy in the knowledge base, organizes the data to recognize patterns, and produces a set of rules that can then be manipulated by an expert system shell.

In a more unconventional approach, Peter Frey presents a BASIC program that forgoes symbolic reasoning and uses bit mapping as the basis for a pattern-matching scheme. Based on John Holland's work on classifying information, Frey's simple expert system can be implemented in almost any standard high-level language. Also using Holland's classifier, Philip Schrodt presents a political expert system in Pascal designed to make short-term forecasts. Schrodt's system relies on an elaborate bit-mapping scheme that matches patterns in a detailed database of past political behavior.

One of the problems encountered in any approach to representing knowledge is that of maintaining consistency and minimizing conflicts in a changing knowledge base. John and Clara Cuadrado tackle this problem with a Prolog frame-based technique. Their decision-support system adjusts its deductions when information is added or deleted and provides "what if" capabilities as well. In a lighter vein, J.-C. Emond and A. Paulissen deal with the problem of incomplete knowledge with their Prolog program, Watson, which simulates the reasoning of a player in a game called CLUEDO.

Many well-known expert systems have been built not with general-purpose programming languages but with specialized rule-based or production systems. Len Moskowitz explains the workings of one such system, OPS5. Although developed and used for years on mainframes, OPS5 is now available in versions for a variety of microcomputers.

For a glimpse at where knowledge representation can lead, our final article in this month's theme examines machine learning, an area still in its infancy. As Angelos Kolokouris explains it, machine learning involves teaching a computer to form concepts. What this requires is a language that can grow as its knowledge increases, which is exactly what Marvin, a Prolog program, does.

—Cathryn Baskin, Associate Editor

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FINDING RULES IN DATA

BY BEVERLY THOMPSON AND WILLIAM THOMPSON

An algorithm for extracting knowledge from data

MUCH OF THE FOCUS of computing in the past has been on collecting, manipulating, and disseminating data. Many people are now saying that the primary focus of computing in the future will be on the collection, manipulation, and dissemination of knowledge and that our view of it will be profoundly changed in the process. Much artificial intelligence research to date has been concerned with representing knowledge in a way that can be efficiently collected, stored, and utilized by a computer.

In this article we describe one method of obtaining knowledge directly from a set of data. This knowledge will be represented in a series of if-then statements called rules. The method used, the ID3 algorithm, was developed by J. Ross Quinlan (reference 1) and is the method most commonly used in the commercial expert systems that employ induction methods to generate rules.

CLASSIFICATION TREES

One structure that has been extensively used to represent knowledge is the classification tree (also called the "decision tree"). A simple example is the best way to show how a classification tree works. Suppose that you want to invest money in a company in the computer industry and are seeking advice from a friend who is a financial expert in that industry. When you call him on the phone, something like the following conversation may take place:

Expert: Is the company a hardware or software company?
You: Software.
Expert: Would you say that the company's main product is new, in midlife, or old technology?
You: Midlife.
Expert: Does this product have any significant new competition?
You: No.
Expert: From what you've told me, it seems that the company's profits should continue to go up.

Figure 1 shows how this same exchange could be represented as a classification tree. This partial tree completes only the branch of the tree that represents the answers you supplied during your conversation. A complete tree would fill in all of the questions and answers that could possibly take place during a consultation session.

Although trees show the relationships that exist among the various components, they can be very difficult to manipulate. One structure that can represent similar information but is easier to use is called a rule. The rule that can be made from the tree in figure 1 is this:

If type is software
and age is midlife
and competition is no
then profit is up.

One rule is made to represent each completed branch of the tree, with the subject of each question being represented by a keyword called an attribute. The question associated with the attribute can be stored along with the rule in the form of a prompt. An example of a prompt would be

prompt type
Is the company a hardware or software company?

The entire collection of rules and

(continued)

Beverly and William Thompson are consultants specializing in the design of knowledge-based systems for microcomputers. They can be contacted at MicroExpert Systems, R.D. 2, Box 430, Nassau, NY 12123.

prompts is called a knowledge base.

Each rule is a single fact that can be easily verified or modified. In addition, work done on expert system shells provides us with many excellent methods for using a set of rules to conduct a consultation. For a detailed description of one of these methods (called a backward-chaining inference engine), see our article "Inside an Expert System" in the April 1985 BYTE.

THE KNOWLEDGE ACQUISITION BOTTLENECK

If the problem of selecting a winning company were as easy as our example makes it appear, there would be no problem stating all of the knowledge about the subject in a simple set of rules and we could make a fortune in the stock market. Unfortunately, the complexity of real-world problems often makes it difficult to design a detailed set of rules. In some problem areas the amount of information needed for a solution is prohibitively large. In others, the knowledge is not well enough defined to put into rules. Even in cases where the problem is manageable, the number of experts with the inclination and the time to work on these systems is small. This situation is often referred to as the knowledge acquisition bottleneck.

In order to solve the problem of acquiring expertise, we should ask ourselves how the experts became experts in the first place. Why, for example, did our financial analyst ask those specific questions? People learn through their experiences. The financial analyst, for instance, constantly absorbs data about different companies, their products, and their financial situations. His mind has the ability to observe patterns in data and organize it. This process allows a person to extract meaning and thus knowledge from data. As we said, the computer has revolutionized the collection and storage of data, but have we really been able to make the most use of that data? Shouldn't it be possible to find some way to organize data to recognize patterns and extract knowledge directly from it? The ID3 algorithm attempts to do just that. No one claims that it works in any way like our own brains, but it does provide a way to produce a classification tree directly from a set of examples within a problem area. Once we can make a classification tree, it is a direct step to rules that can be manipulated by an expert system shell.

To illustrate how the algorithm works, let's return to the problem of predicting whether a given company's profits will increase or decrease. This time, let's suppose that when you ask your friend for advice he tells you that he makes it a policy not to give financial advice to friends. Instead, he suggests some magazines that you could read to familiarize yourself with the ups and downs of the industry. You take his advice but find it's very difficult to make use of all the reading material. So you make a table that lists some of the companies, some facts about them, and whether their profits have increased or decreased in the last quarter. A sample of this table is shown in table 1. The labels on the columns "profit," "age," "competition," and "type" are the attributes for which the values are stored in the table. Each row in the data table is called an example. The first attribute, "profit," is called the class attribute. Your goal is to determine a relationship between the class attribute and the values of the other attributes. The first example says that "profits were down in a company whose product was old, had no significant competition, and which produces software." You can see that the table alone does not give you much insight into predicting when a company's profits are likely to increase. What is needed is a way to use the examples in the table to produce a classification tree.

BUILDING THE CLASSIFICATION TREE

To build a classification tree, you select one of the attributes to be the starting point or root node of the tree. Once you select this attribute, you split up (partition) the example set into a number of smaller tables, each containing examples with the same value of the selected attribute. If you select "age" as the root of the tree, the table will be split into the sets shown in figure 2. You can see in figure 2 that when "age" has the value "old," the value of the class, "profit," is always "down." When the value of "age" is "new," the class value is always "up." In these two new example sets, no further classification is necessary. However, in the example containing "age = midlife," you must select a new attribute and split the set again. Figure 3 shows the results of a split on the attribute "competition." Since each partition now contains only a single value for the class attribute, the tree-building process is complete.

You can produce a set of if-then rules from this tree by following each branch from the root to a terminal node. Each rule is a series of conditions consisting of attribute and value pairs, followed by a single conclusion that contains the class and the corresponding class value. The inter-

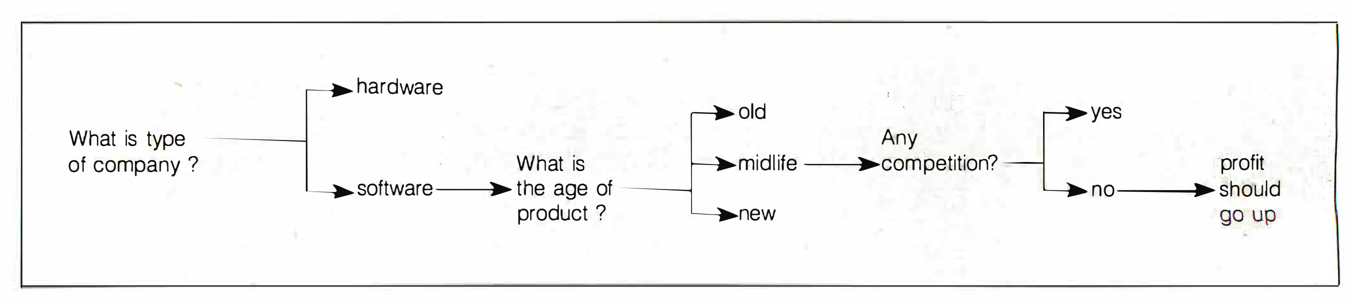


Figure 1: *Classification tree showing the results of one consultation session.*

mediate nodes and their branches form the conditions of the rules; the terminal nodes form the rules' conclusions. For example, following the first branch on the right results in the rule

If age is old
then profit is down.

One rule is produced for each terminal node of the tree. The rules that can be formed from this tree are shown in figure 4.

Figure 3 illustrates an interesting side effect of the tree-building process. Even though the original example set contained three attributes, you did not need the attribute "type" to classify the examples in the set. This is a valuable result because it can reduce the amount of data that needs to be collected. Brieman et al. (reference 2) used a classification-tree-building technique called CART to classify the mortality risk of heart attack victims. This process allowed them to reduce the number of attributes in the data set from 19 to 3.

Why This Tree?

The tree in figure 3 is certainly not the only possible tree that could have been generated from this set of examples. Rather than selecting "age" as the first attribute on which to split the example set, you could have selected

(continued)

Table 1: *Table of example set.*

Profit	Age	Competition	Type
Down	Old	No	Software
Down	Midlife	Yes	Software
Up	Midlife	No	Hardware
Down	Old	No	Hardware
Up	New	No	Hardware
Up	New	No	Software
Up	Midlife	No	Software
Up	New	Yes	Software
Down	Midlife	Yes	Hardware
Down	Old	Yes	Software

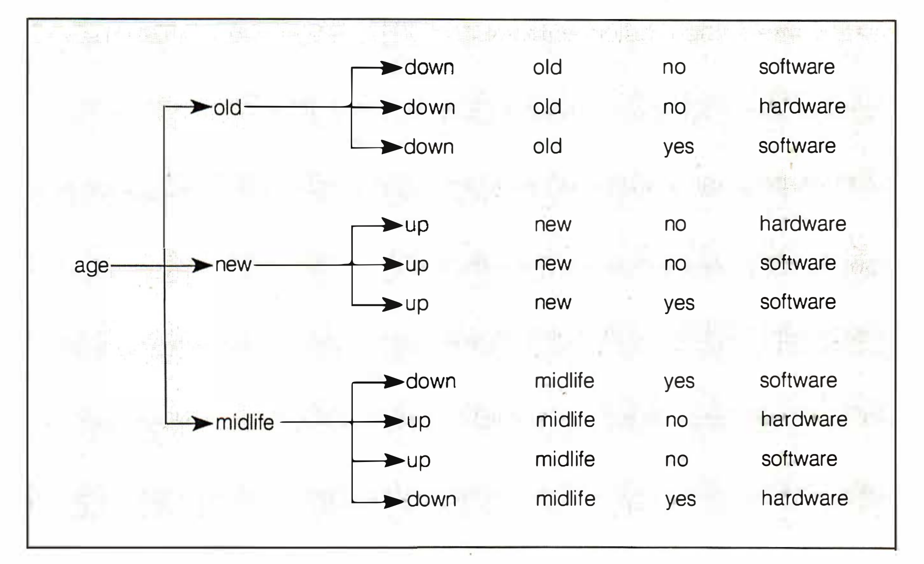


Figure 2: *Example set from table 1 split on attribute "age."*

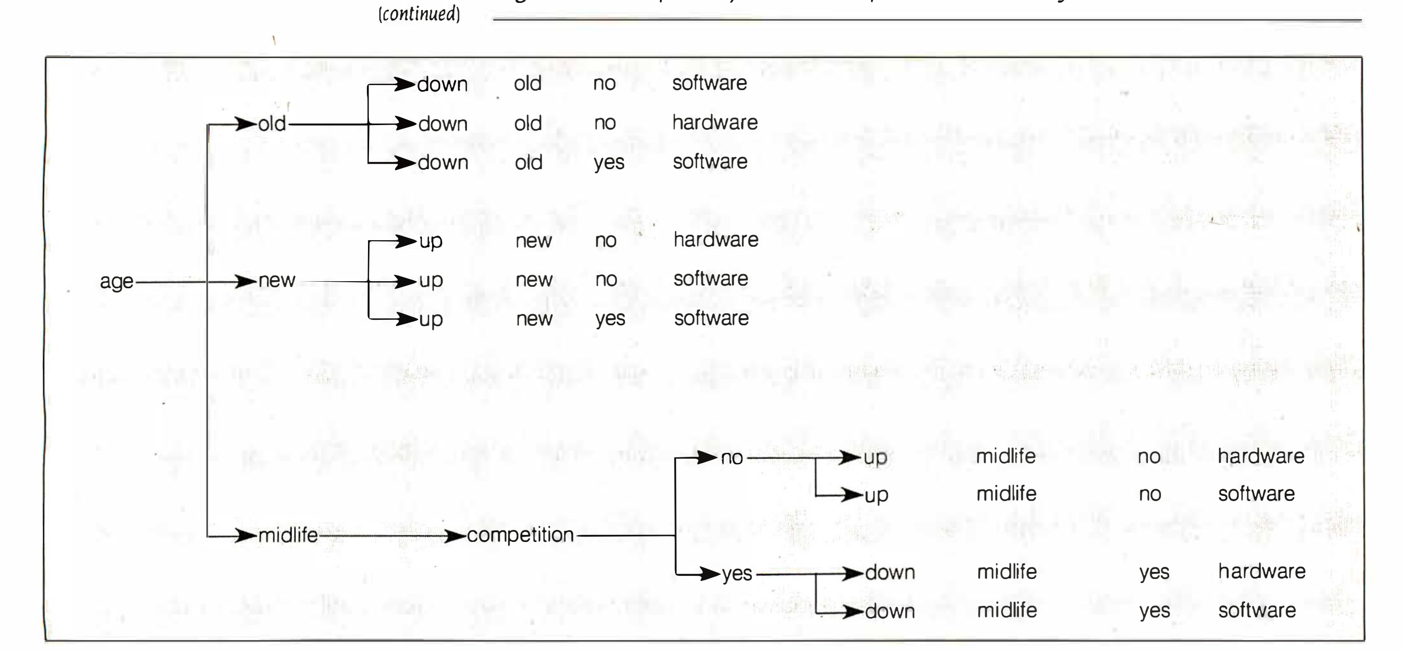


Figure 3: *Example set of figure 2 after second split—this time on "competition."*

one of the other attributes. This would have resulted in a different tree and a different set of rules. Since some attributes tell us more about how to classify an object than others (in our example, "type" was not even needed), it is important to split the example set using attributes that lead to efficient classification trees. Put another way, how do you measure the amount of information about classification contained in a single attribute?

ENTROPY

If we turn to communication theory, we find that there is a precise measure of information called entropy. Applying this concept to the classification problem, we find that if an object can be classified into one of several different groups, the entropy is a measure of the uncertainty of the classification of that object. As the entropy increases, the amount of information that we gain by knowledge of the final classification increases. Mathematically, if an object can be classified into N different classes, $c_1, \ldots, c_N$, and the probability of an object being in class i is $p(c_i)$, then the entropy of classification, $H(C)$, is

$$H(C) = -\sum_{i=1}^{N} p(c_i) \log_2 p(c_i)$$

If you are a bit rusty on logarithms, recall that $\log_2(x) = y$ means the same as $2^x = y$ or, more plainly, the log to the base 2 of any number is the number of bits that it would take to represent that many different objects. Consequently, $\log_2(16) = 4$ tells you that it takes 4 bits to uniquely represent 16 different objects. (All logarithms mentioned in this article are assumed to be taken to base 2.)

Let's apply the entropy formula to the example set in table 2. In this set there are two possible values for the class attributes, "up" and "down." The probability (actually the frequency of occurrence) of the class having the value of "up" is 5 out of a total sample set of 10, or 5/10. The probability of "down" is also 5/10. The entropy of classification for the total set is

$$\begin{aligned} H(C) &= -p(\text{up}) \log p(\text{up}) - p(\text{down}) \log p(\text{down}) \\ &= -5/10 \log (5/10) - 5/10 \log (5/10) \\ &= 1.00 \end{aligned}$$

Although this number represents the uncertainty about profits going up or down based on the data in table 1, it does not tell us anything about the amount of information contained in the individual attributes.

If age is old
then profit is down.

If age is new
then profit is up.

If age is midlife
and competition is no
then profit is up.

If age is midlife
and competition is yes
then profit is down.

Figure 4: *Rules produced from the classification tree of figure 3.*

Table 2: *Part of the example set split on "competition."*

Competition	Profit
No	Down
No	Up
No	Down
No	Up
No	Up
No	Up
Yes	Down
Yes	Up
Yes	Down
yes	Down

CALCULATING THE ENTROPY OF CLASSIFICATION OF AN ATTRIBUTE

What we really want to know to help us decide the attribute on which to split is the entropy of classification after deciding on a particular attribute. This entropy represents the amount of uncertainty about a particular outcome, so we'll want to split on the attribute that results in the smallest entropy of classification.

The first step in calculating the entropy of classification after deciding on a partitioning attribute, symbolized by $H(C|A)$, is to split the table into subtables where each example has the same value of the partitioning attribute. Table 2 shows a partition of the example set after splitting on the attribute "competition." The entropy of each subtable, $H(C|a_j)$, is calculated for each value of the attribute, a_j. $H(C|a_j)$ is given by the expression

$$H(C|a_j) = -\sum_{i=1}^{N} p(c_i|a_j) \log p(c_i|a_j)$$

The function $p(c_i|a_j)$ is the probability that the class value is c_i when the attribute has its jth value.

We can now calculate the entropy of each subtable:

$$\begin{aligned} &H(C|\text{competition=no}) \\ &\quad = -p(\text{up}|\text{competition=no}) \\ &\quad \times \log p(\text{up}|\text{competition=no}) \\ &\quad - p(\text{down}|\text{competition=no}) \\ &\quad \times \log p(\text{down}|\text{competition=no}) \\ &\quad = -4/6 \log (4/6) - 2/6 \log (2/6) \\ &\quad = 0.918 \end{aligned}$$

$$\begin{aligned} &H(C|\text{competition=yes}) \\ &\quad = -p(\text{up}|\text{competition=yes}) \\ &\quad \times \log p(\text{up}|\text{competition=yes}) \\ &\quad - p(\text{down}|\text{competition=yes}) \\ &\quad \times \log p(\text{down}|\text{competition=yes}) \\ &\quad = -1/4 \log (1/4) - 3/4 \log (3/4) \\ &\quad = 0.811 \end{aligned}$$

The expression $p(\text{up}|\text{competition=no})$ is the probability that the class value is "up" when the value of the attribute "competition" is "no." It is just the number of times class "up" appears in a row with "competition" equals "no" divided by the total number of cases in which "competition" equals "no."

In order to find the entropy of the entire table after the split, $H(C|\text{competition})$, we must take the sum of the entropy of each of the values of the attribute multiplied by the probability that the value will appear in the table. Stating all of this concisely, the entropy of classification after choosing a particular attribute, $H(C|A)$, is the weighted average of the entropy for each value a_j of the attribute.

Mathematically this is expressed as

$$H(C|A) = \sum_{j=1}^{M} p(a_j) \; H(A|a_j)$$

M is the total number of values for the attribute A.

In this example this gives

(continued)

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```
( ( down  old      no   software  )
  ( down  midlife  yes  software  )
  ( up    midlife  no   hardware  )
  ( down  old      no   hardware  )
  ( up    new      no   hardware  )
  ( up    new      no   software  )
  ( up    midlife  no   software  )
  ( up    new      yes  software  )
  ( down  midlife  yes  hardware  )
  ( down  old      yes  software  ) )
```

Figure 5: *Lists used to represent the example set.*

```
( ( profit  down  up )
  ( age  old  midlife  new )
  ( competition  no  yes )
  ( type  software  hardware ) )
```

Figure 6: *List used to store attributes and their values.*

$H(C|\text{competition})$
$= 6/10 \times 0.918 + 4/10 \times 0.811$
$= 0.8752$

If we perform these same calculations for the other attributes in our example, we find that $H(C|\text{age}) = 0.4$ and $H(C|\text{type}) = 1.0$. Since $H(C|\text{age})$ gives us the smallest entropy and thus the least uncertainty, "age" is the best attribute to select for the initial split.

IMPLEMENTING THE ALGORITHM

To implement this algorithm we need to make some decisions about how to represent the example tables in the program. We will store the table of examples as a list. Each element of the list is another list that contains one example. Figure 5 shows the list containing the example set from table 1. Each list is enclosed in parentheses. Even though considerable overhead is associated with the use of list structures in a program, lists provide a great deal of flexibility and allow us to use a single representation for both the examples and the final classification tree.

We will also use a list to keep track of the attributes and their values. This is another list of lists. The first sublist consists of the class name and associated class values. The other sublists contain the attribute names and each attribute's values. Figure 6 shows the attribute list for the example set.

The actual tree-building procedure is performed by a function called classify. If you pass an example list to this function, it returns the classification tree for that example set. This tree is also represented by a list. The first element in the list is an attribute or class name, and it is followed by a series of lists. Each list contains a class value if the first item was the class name; otherwise, each list contains a value for the attribute followed by the tree produced by classifying the partition of the example set that has that value. In other words, classify is a recursive procedure that either returns the class name and the class value of the example set or calls itself to classify the new partitioned example set. The clearest way to explain classify is to demonstrate how it would process our example set.

Figure 7 shows a list that is equivalent to the tree returned by classify. By calculating $H(C|A)$ for each attribute, classify has chosen "age" as the attribute on which to split. It returns the attribute name followed by three lists. Each list contains a value of the attribute followed by the classification of the appropriate subset of examples. The calls to classify in the first two lists (the values "old" and "new") will result in no further recursion because each of the lists contains only a single class. In both cases, classify will return the class name, "profit," and the appropriate class value. The third list requires a new partitioning of the example set. Figure 8 shows the results when classify splits the new example set on "competition." The final tree returned

(continued)

```
( age   ( old       classify  ( ( ( down  old      no   software  )
                                    ( down  old      no   hardware  )
                                    ( down  old      yes  software  ) ) ) )

        ( new       classify  ( ( ( up    new      no   hardware  )
                                    ( up    new      no   software  )
                                    ( up    new      yes  software  ) ) ) )

        ( midlife   classify  ( ( ( down  midlife  yes  software  )
                                    ( up    midlife  no   hardware  )
                                    ( up    midlife  no   software  )
                                    ( down  midlife  yes  hardware  ) ) ) ) )
```

Figure 7: *The list equivalent to the tree in figure 2. This list is returned after the first call to the* classify *routine.*

```
( age ( old      ( profit ( down ) ) )
      ( new      ( profit ( up   ) ) )
      ( midlife  ( competition  ( no   classify ( ( ( up    midlife  no   hardware )
                                                    ( up    midlife  no   software ) )

                                ( yes  classify ( ( ( down midlife yes software )
                                                    ( down midlife yes hardware ) ) )
```

Figure 8: *The list equivalent to the tree in figure 3.*

```
( age ( old      ( profit ( down ) ) )
      ( new      ( profit ( up   ) ) )
      ( midlife  ( competition  ( no   ( profit ( up   ) ) )
                                ( yes  ( profit ( down ) ) ) ) ) )
```

Figure 9: *The final list returned by the* classify *routine.*

by classify is shown in figure 9. If you examine the "list of lists" in figure 8, you can see that its structure is similar to the classification tree shown in figure 3.

The classify function produces the tree in a depth-first manner. In our example that means classify would continue to the end of the branch for "age" is "old" before looking at the other values for "age."

HANDLING CONFLICTS IN THE DATA

Conflicts among the examples can lead to the generation of erroneous rules. A conflict occurs when two examples contain identical values for all attributes but have different class values. A conflict usually signifies that the attributes chosen are inadequate for the classification task. You can remove this problem by introducing additional attributes. Deciding which new attributes to include is a task for an expert in the problem domain being considered, but identifying conflicts is relatively easy. Since each example is stored as a list, you can recognize a conflict by comparing the list representing an example against each of the other lists. A conflict occurs when the tails (the entire list except for the first item) of two lists match, but the first items on the list are different.

"DON'T CARE" VALUES

When creating examples, we find it useful to specify that a particular attribute does not play a role in the classification. We use a special symbol, called a "don't care" value, to indicate this fact. For instance, (down old no *) indicates that if the value of the attributes "age" and "competition" are "old" and "no," respectively, the class value is "down" no matter what the value of "type." An asterisk represents a "don't care" value. Examples containing "don't care" values are expanded into a new set of examples, each containing one of the possible values for the "don't care" attribute. The example above would be expanded to (down old no hardware) and (down old no software).

ATTRIBUTES WITH NUMERIC VALUES

All of the attributes in the example set had values chosen from a limited group of possibilities. Suppose that instead of assigning the values "old," "new," and "midlife" to the attribute "age," you wanted to assign numeric values. In this case, you would use the numeric values of "age" to create a set of new attributes that contain the ranges of possible values. For example, assume that you have four companies with products aging 6, 10, 16, and 36 months. You would make three new attributes, each representing the range formed by splitting the consecutive values at their midpoints. The new attributes would be "age < 8,"

(continued)

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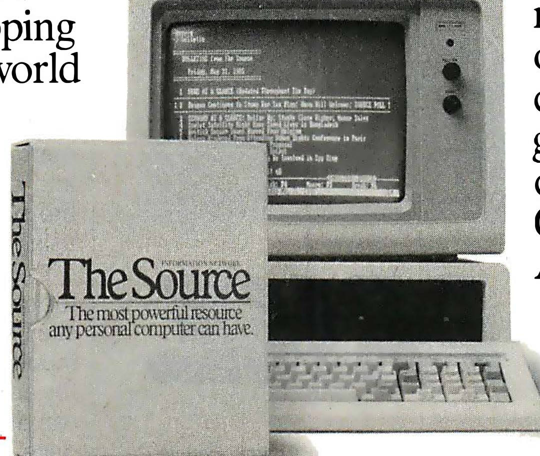
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"age < 13," and "age < 26." The values in the original table under "age" are used to determine if the value of the new attributes is "yes" or "no." The entropy of classification after splitting is calculated for each new attribute along with the other attributes to determine the best attribute to use to partition the data set.

The Completed Program

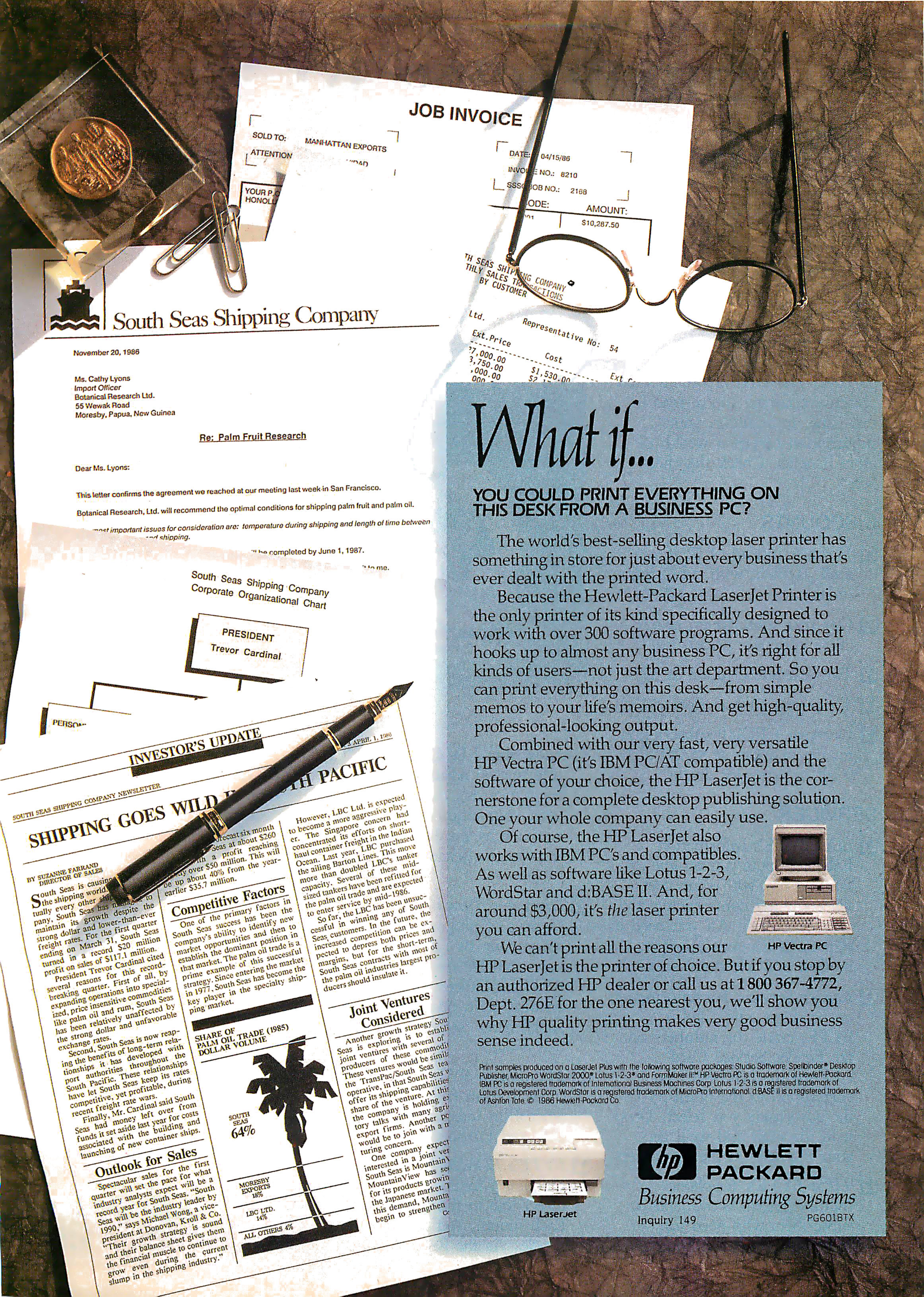
A Turbo Pascal program called INDUCE for the IBM PC and compatibles implements the techniques described above. [*Editor's note*: INDUCE *is available on disk, in print, and on* BIX*; see the insert card following page 352 for details. It is also available on* BYTE*net*; *see page 4.*] The program contains a collection of low-level routines for the manipulation of the list structures described in this article. Since Turbo Pascal is not optimized for list processing, the program is slow compared to some of the commercial implementations of the ID3 algorithm, but we hope that by examining the commented source code, programmers can gain some insight not only into the ID3 algorithm but also into the power of symbolic computation using list-like structures.

The program produces rules in the format accepted by the expert system shell MicroExpert, but you can easily modify the program to produce rules for another expert system shell. You can also modify the program to produce Prolog sentences.

Also available is Crossref, a parser that reads and parses rules that use the same rule syntax as the one we have described. A description of this program and how to write an inference engine that uses the rules can be found in our April 1985 article. [*Editor's note*: *Crossref is available on* BIX *and* BYTE*net*.] ■

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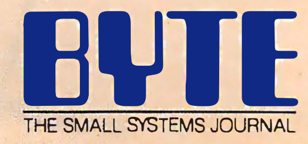
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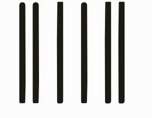
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A BIT-MAPPED CLASSIFIER

BY PETER W. FREY

This unconventional approach yields a small, fast, pattern-oriented expert system

IN THE PAST DECADE, expert systems have matured from laboratory curiosities to useful commercial products. They are an evolutionary outgrowth of early work in artificial intelligence on search-based problem solving and theorem proving. In their most common form, these systems use simple IF . . . THEN productions to represent a wide range of ideas, concepts, and actions in a uniform data structure. Conclusions are drawn and advice is given by reasoning in a sequential manner. Sometimes the expert system uses forward chaining by starting with initial observations and working through the list of productions until it can derive an appropriate conclusion. In other instances, the inference engine works by backward chaining. In this case, the system starts with the desired conclusion and attempts to work through the production list to find a link to the conditions of the specified problem.

CLASSIFIER SYSTEMS

In what follows, I describe an unconventional expert system that is based on pattern recognition rather than on reasoning. This approach can be implemented in conventional programming languages on an inexpensive desktop system. The architecture is surprisingly simple, and the program can be modified or extended easily. When implemented cleverly, expert systems based on this approach can provide advice or conclusions rapidly even when the knowledge base is extensive. I hope to show that a simple method can sometimes be a good one.

The literature on expert systems shows that most existing programs function as categorizers. A set of environmental stimuli (features or symptoms) is classified into one of many possible categories. For example, medical diagnosis is performed by assigning each set of symptoms to a specific illness category. Other diagnostic programs work in a similar manner to deal with mechanical malfunctions in automobiles, airplanes, or air-conditioning systems. Systems for speech recognition or visual object identification can also be treated as classification systems. Expert systems that provide travel recommendations or suggest where to drill for oil can also be placed in this same category.

The pattern-recognition program described in this article is based on a familiar concept that is commonly known as a classifier system. The terminology I use is based on the recent work of John Holland (see reference 1) at the University of Michigan. Information about the set of conditions is encoded as a string of bits where each bit represents a specific feature that is typically binary in nature (present or absent). This bit string, which can be 10 or 12 bits for simple problems or several hundred bits for complex problems, is usually referred to as a *message*. For example, a system for recognizing a particular person at a sports event might have specific bits representing such features as blue eyes, black hair, 6 feet tall, 190 pounds, blue jacket, brown pants, gray sideburns, shoulder-length hair, wire-rim glasses, etc. The set of features can be broad enough to uniquely categorize thousands of different individuals. The message for any given person would have a 1 in locations representing specific attributes that

(continued)

Peter W. Frey (Northwestern University, 2021 Sheridan Rd., Evanston, IL 60201) is a professor at the Cresap Neuroscience Laboratory. He has interests in decision processes, expert systems, and machine learning.

are present and a 0 in locations for features that are not present. This bit-map approach is very general and yet is extremely simple to implement.

A particular pattern of features, such as those associated with a target person, is denoted by a bit-string pattern called a *classifier*. Classifiers are more complicated than messages because they are based on a multi-letter alphabet rather than a two-letter alphabet. One way to represent a classifier in a binary system is to use one bit string to denote present or absent and other bit strings to represent the relative importance of different bits. I will refer to the first string as the classifier and the others as *classifier masks*. Eleanor Rosch (see reference 2) has argued persuasively that natural categories do not have fixed boundaries. Instead, members of a category vary in their characteristics depending on how many of their attributes are central or peripheral to the category. To represent this aspect of categorizing people, objects, or events, we employ three classifier masks specifying which attributes are absolutely essential to the category (type A), which ones are usually present (type B), and which ones are sometimes present (type C). This strategy permits flexibility in defining category prototypes (the classifiers) that seem necessary for real-world applications.

To perform a task such as finding a specific person at a sports event, you would create a classifier that specifies which attributes among those possible are possessed by the target individual. A message would then be created for each individual at the sports event by specifying the attributes that each possessed. The classifier would then be compared to each message, and the message that was most similar would be identified as the target individual. This strategy is conceptually simple. Note, however, that several very important matters need to be considered. In particular, you must specify the global set of attributes. The effectiveness of the process depends critically on a judicious choice of attributes. The process can discriminate among similar individuals only if the bit map includes the right features. Knowing in advance what these features should be usually requires an expert's knowledge.

The second major problem of the description given above is the phrase "most similar." There are many ways to measure similarity. With simple bit maps, the most obvious measure of similarity between a message and a classifier is the number of relevant bits in common. A relevant bit is one indicated by the classifier mask as being important. By comparing each of the three classifier masks with the message, you can determine if all the essential bits (type A) in the classifier are matched exactly, how many of the type B bits are set properly, and whether any of the type C bits match.

In most cases, you need to empha-

size some bits more than others. Some attributes are absolutely critical (type A). If one or more of these are absent, the message is not compatible with the classifier. In a sense, each of these crucial attributes is given an absolute veto in the matching process. Type B and type C attributes influence the judgment of similarity but in a less central way. The proportion of type B matches is important because bits that do not match are negative evidence. Type C attributes are diagnostic when present but not damaging when absent. To be most similar to a classifier, a message must match all the critical features exactly and match more type B and type C features than any other message that meets the type A conditions. This implementation of the similarity idea provides a very powerful method for approximate pattern matching.

Another device that increases the generality of this procedure is to represent higher-level concepts with more than one classifier pattern. For example, you might wish to identify a specific person at a sporting event and not know what clothing the person was wearing. But you might know that the person was likely to be wearing one of three favorite outfits. An easy way to deal with this ambiguity is to define three separate classifiers for the target person, one for each outfit. These three classifiers would be identical except for the bits representing clothing. This capability of defining more than one classifier for a given category is a powerful way to deal with concepts that are not precisely defined. In medical diagnosis, there are illnesses in which the pattern of symptoms is quite different for men and women or different for children and adults. These complexities are easy to deal with when separate classifiers can be defined for each special case.

When classifiers differ in the number of relevant features, the yardstick for measuring similarity needs to be modified to take into account the specificity of the classifier (see reference 1). One classifier is said to be more specific than another when it has more bits that are designated as relevant. Similarity is then defined as a joint function of the proportion of relevant bits that match and the total number of relevant bits.

An additional complication in many expert systems is that all aspects of the problem are not known in advance. For example, in medical diagnosis, it is usually necessary to ask the patient a series of specific questions or to administer specific medical tests in order to uncover the relevant information. This process of sequential information acquisition complicates the procedure since the computer system must decide in what order to administer the questions and/or tests. In medicine as well as in other applications, there is a financial cost

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Inquiry 65

associated with information gathering, and experts should be skilled at making the proper diagnosis at a minimal cost. This complication can be addressed within the message-classifier system by defining a message mask that indicates which attributes are known at any given time. Similarity between a message and a classifier is then measured by excluding features for which no information is available as well as excluding features that are not marked by the classifier mask.

You can develop many strategies for determining what feature to ask about next. A simple strategy is to identify the classifier that currently has the greatest similarity to the message and ask about its unknown features. If the answer to the question increases the degree of similarity, continue to seek information relevant to this classifier. If the answer decreases the similarity, check to see if another classifier is now more similar. If so, switch the line of questioning to features that are relevant to the second classifier. This strategy approximates the hypothesis-testing approach that is commonly observed in humans. Doctors try to gather information that will confirm or disprove the most likely diagnosis. Criminal investigators also usually concentrate their information-gathering efforts on their prime suspect.

IMPLEMENTING A BIT-MAPPED CLASSIFIER SYSTEM

The pattern-recognition system described above is well suited to the architecture and instruction set of a modern microprocessor. In particular, registers and memory locations are physical representations of a bit map. There are instructions such as EQUAL, NOT-EQUAL, AND, OR, and XOR that are designed to compare and manipulate whole strings of bits as a single operation. The bottleneck that determines execution speed is the time required to match classifiers with messages. In some applications there are many messages and a few classifiers. In others, there is only one or a few messages and many classifiers. For medical diagnosis, you might

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Knowing which attributes to include separates an expert from a novice.

have a single message with 500 or 600 features (all of the symptoms the patient might have) and 300 or 400 classifiers (symptom patterns that fit particular illness definitions). To match this long message against each long classifier, you want to compare bit patterns at a very high rate.

To implement this process, the computer starts by performing an XOR operation between the message and the classifier. The resulting string is negated (NOT), reversing all 0s and 1s. Next, an AND operation is performed between the string representing the message mask and the string representing one of the classifier masks, setting the bits in those locations where the feature is relevant and is currently known. This hybrid mask is then ANDed with the result of the first two operations. The number of bits set in this last string provides a count of the relevant matching bits between the classifier and the message. This process requires two ANDs, one XOR, and one NOT to produce the two relevant strings. Some mainframes have machine-level instructions that count the number of bits that are set in a word. Microprocessors do not have this instruction, so the only way to do a speedy bit count is to examine the word in 8-bit sections and use a table with 256 entries to look up the proper bit counts. This is not very elegant, but it is reasonably fast. For messages that are longer than the word size of the machine (usually 16 or 32 bits), the matching process must be repeated in 16- or 32-bit segments until the entire message has been examined. For most applications, the matching algorithm described above executes rapidly. For the program described below, you get responses in about 2 to 3 seconds, using a BASIC interpreter.

Table 1: A *partial list of architectural attributes.*

Date of Construction

1. before 1820
2. between 1820 and 1880
3. between 1880 and 1940
4. after 1940

Roof Pitch

5. flat
6. low slope (less than 30 degrees)
7. moderate slope (30 to 45 degrees)
8. steep slope (more than 45 degrees)
9. combination of the above

Exterior Walls

10. wood
11. stone
12. brick
13. stucco or adobe
14. combination of the above
15. other

Junction Between Roof and Exterior Wall

16. absence of eaves (little or no overhang)
17. parapet (exterior wall extends above edge of roof)
18. slight overhang with exposed rafters
19. slight overhang with boxed rafters
20. wide overhang with exposed rafters
21. wide overhang with boxed rafters
22. other

An Example Based on House Architecture

The advantages of this bit-mapped approach can be demonstrated by applying the method to a realistic example. I have chosen house architecture because the ideas and terminology are familiar to a general audience. Because I am not an expert on this topic, the program's knowledge is derived almost entirely from a recent book (see reference 3). Unlike many examples that are based on "toy" problems, house architecture provides a level of complexity and conceptual richness that is equivalent to applications addressed by serious commercial expert systems. The implementation I describe covers over 58 distinct house styles and involves over 160 descriptive attributes. It can be extended without any major changes to encompass an even broader range of architectural themes and subtypes.

The first step in developing a knowledge base is to specify the attribute classes that define group membership. To identify the architectural style of a house, you focus on specific features, including date of construction, roof shape, roof pitch, nature of the junction between the roof and the exterior wall, material composing the exterior wall, type of windows, shape and decorations of the front door, ornamental details, and a multitude of other possible features.

A partial list of relevant attributes is presented in table 1. The list is organized by general categories starting with date of construction. Any given house is designated by creating a bit map (a message) that has a 1 set in the bit position for each attribute that is present and a 0 set in the bit position for each attribute that is not. The number associated with each attribute represents the location of this attribute in the bit map. In the beginning, the proper identity of these bits is unknown. Appropriate values are assigned in a sequential fashion on

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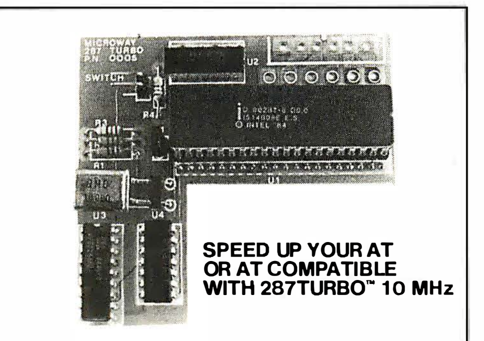
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the basis of information provided by the human user during a question-and-answer session. Attributes are selected to capture the distinctive features of each house style and to discriminate among types that may have many similarities. Knowing which attributes to include on the list is one of the things that separates an expert from a novice.

When a conventional rule-based expert system has difficulty making a proper categorization, the knowledge engineer typically modifies one or more existing rules or devises additional rules. The system I describe adjusts for weak performance in a similar manner by modifying or adding to the attribute list. Almost any two styles can be distinguished by identifying critical differences and adding features that are sensitive to these differences. A powerful technique in this regard is to note which attributes never appear and include their negations as part of the classifier.

Sample classifiers are presented in table 2. Each architectural style is defined in terms of features from the attribute list that are assigned a type A (must be present), type B (usually present), or type C (sometimes present) role. Each number corresponds to a bit in a descriptive string. An attribute in the table that is underlined is one that should not be present (negation). Note that the Italian Renaissance style is defined with two classifiers because there are two distinct variations on the theme. These examples give the flavor of this flexible way to represent knowledge. By using messages and classifiers in combination with a carefully developed attribute list, the method can easily deal with a broad range of objects and concepts.

The program HOUSE.BAS was written in Microsoft BASIC version 2.0 to implement this system on the Macintosh. Double-clicking on the file loads MS-BASIC, which then executes the program. [*Editor's note:* HOUSE.BAS *is available on disk, in print, and on* BIX; *see the insert card following page* 352. *It is also available on* BYTE*net; see page* 4.] You will see a banner announcing HOUSE.BAS's purpose and will have to wait several

(continued)

Table 2: *Sample classifier definitions. The number indicates the bit position in the classifier string; an underlined value indicates negation.*

Queen Anne Victorian

A. 3, 8, 80, <u>83</u>
B. 41, 131
C. 14, 42, 43, 45, 48 49, 55, 57, 60, 69, 82, 84, 105, 116, 117, 118, 120, 121, 122, 132, 133, 134, 153

Colonial Revival

A. 3, 60
B. 7, 19, 26, 61, 83
C. 24, 25, 30, 31, 32, 55, 70, 81, 87, 89, 91, 96, 116, 135, 136, 137, 138

Tudor

A. 3, 8, <u>41</u>
B. 90, 105
C. 12, 23, 33, 63, 64, 98, 126, 130, 156

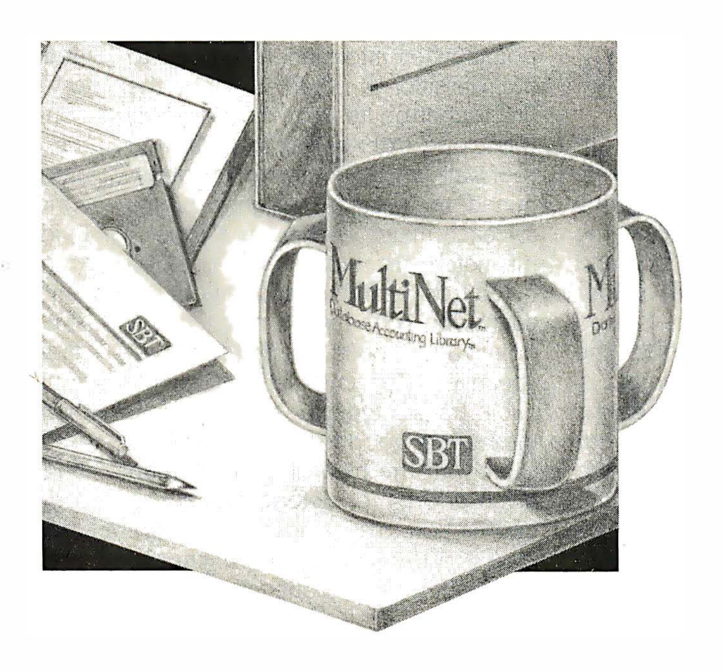
Italian Renaissance I

A. 3, 6, 21, 93
B. <u>10</u>, 115
C. 25, 26, 65, 71, 76, 109, 110, 136, 137

Italian Renaissance II

A. 3, 5, 11
B. 83, 116, 123
C. 25, 26, 43, 44, 65, 71, 76, 136, 137

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The bit-mapped classifer approach is a model of organizational simplicity.

seconds while lists and masks are loaded. Click inside the banner window when the program is ready. Initially, you are asked to indicate the date of construction by pointing and clicking the mouse on one of four choices. A similar procedure is used to determine the roof slope, the material composing the exterior walls, and the type of junction between the roof and exterior wall. After these four attributes have been determined, the program continues by asking about one feature at a time. I have also added graphic examples of three features, namely, a board-and-batten door, a front door with recessed panels, and pilasters alongside the front door (see figure 1). These are included to demonstrate how an expert system can define unknown technical terms. Unfortunately, I don't have the time to develop a graphic depiction of the other 157 features. Questions then follow in a variable sequence until the program determines that it has only one candidate that is consistent with the information.

The reasoning process that is used by this program is remarkably simple. A goodness-of-fit value is computed for each classifier by accumulating points when information relevant to the classifier is obtained. After the first four attributes (construction date, roof slope, exterior wall material, and roof-wall junction) have been determined, the program assigns 5 points for each match. If there is a type A mismatch, the house type is eliminated from further consideration. For each type B or type C mismatch, 5 points and 1 point are deducted, respectively. The cumulative total for each house type is treated as a measure of goodness of fit. The classifier with the highest score is then given priority for determining which information to seek next. If there are type A attributes that are unknown, a question about one of these is asked next. If all of the type A attributes are known, type B questions and then type C questions are posed to the user. If the score of the leading candidate drops below that of a rival, the questioning process immediately switches to the rival to determine attribute selection.

There are two termination conditions. If one classifier accumulates a score that exceeds a predetermined threshold, this house type is declared the winner and no further information is needed. The notion is that the weight of evidence for this hypothesis is so strong that the decision is obvious. In this case, there is no need to waste your time with further questioning. On occasions when none of the classifiers has an overwhelming amount of support, the termination condition is much more conservative. Evidence is collected until the program can determine that the leading candidate has more support than any of its competitors could have. This is determined by noting which questions have not yet been asked and then doing a hypothetical calculation assuming negative outcomes for the leading candidate and positive outcomes for all the rivals. If the leader's projected score still exceeds those of its rivals, there is no need to seek further information. In this eventuality, the winner is announced and the process is stopped. For HOUSE.BAS, the program will identify the house type (if possible) and then loop indefinitely at this display until you halt it by typing the sequence command-period.

There are alternative reasoning strategies that are much more sophisticated than the one described above. You could assign subjective probabilities to each piece of evidence in a categorical fashion (e.g., 0.98 to type A items, 0.8 to type B items, and 0.3 to type C items) and then employ Bayesian or Dempster-Shafer reasoning to reach a decision. I am not eager to add these complexities until my simplified approach shows serious deficiencies. Because people apparently solve these problems without resorting to complex calculations, it seems reasonable to start with a machine model that avoids heavy number crunching.

Figure 1: *The* HOUSE.BAS *program in operation.*

EVALUATION AND EXTENSIONS

The bit-mapped classifier approach described above is a model of organizational simplicity. The knowledge base and reasoning mechanism are separate entities. Each can be modi-

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fied or extended without affecting the other. Because of this structure, you can diagnose performance problems quickly and easily. The transparency of the process greatly simplifies the knowledge engineer's task. When the program has difficulty categorizing a particular house or when a misclassification occurs, you can usually determine why the problem occurred and what needs to be done to correct it.

The development process can be aided by building tools that provide the knowledge engineer with rapid access to information that is frequently needed. To aid you in modifying this program, I have included two special menus, Debug and Crosstabs. The Debug menu provides a bit-map representation of the current message or its most likely classifier and its masks. Crosstabs allows you to select a house type and see a list of all features that are relevant, or select a feature and see a list of relevant houses.

Another characteristic of these bit-mapped classifier systems is that they can be implemented in almost any standard high-level programming language. You can use Pascal, C, FORTRAN, BASIC, and many others. No special hardware is required, and the memory and computational demands are such that even an inexpensive microcomputer system is a feasible host. The ultimate yardstick, however, will be the functional utility of the approach. In the next few years, my students and I and perhaps others will examine various applications for this type of expert system. We will have confidence in the ultimate success of the approach only after we have field results that are consistent with a positive evaluation.

John Holland has worked with classifier systems for several years in a more complicated context. His objective has been to develop a conceptual basis for using this method of knowledge representation to do sequential reasoning and self-modification (learning). What is encouraging about the approach described above is that Holland's ideas can be applied to achieve much more powerful results than simple classification. If my bit-mapped classifier approach proves to work effectively on categorization problems, I will be very interested in exploring extensions of this approach that use Holland's bucket brigade and genetic algorithm. Since no special hardware or software is required, I am hoping that many of BYTE's readers will join the expedition. ■

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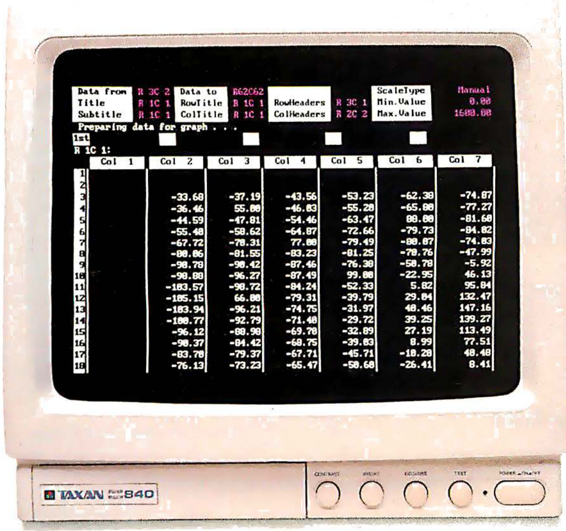


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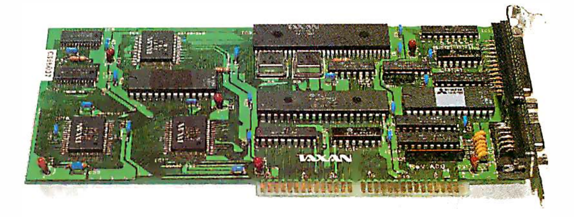
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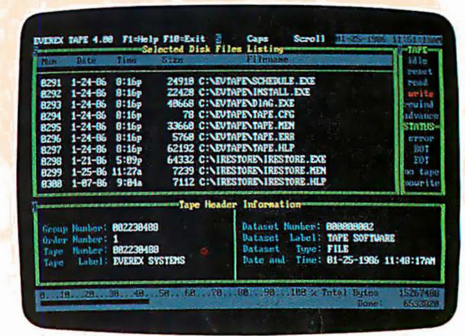
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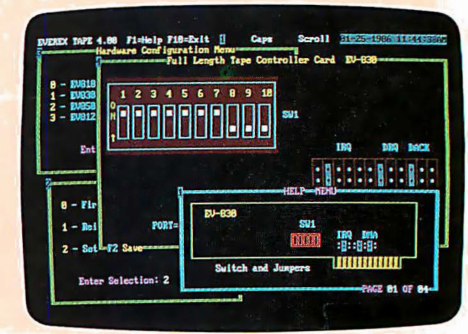
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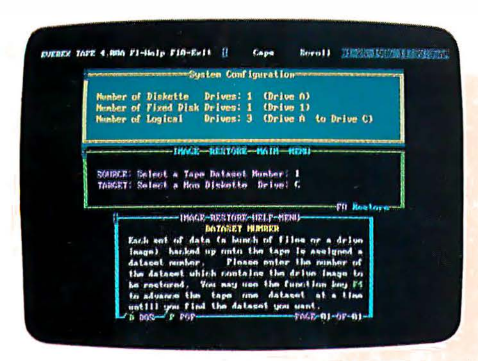


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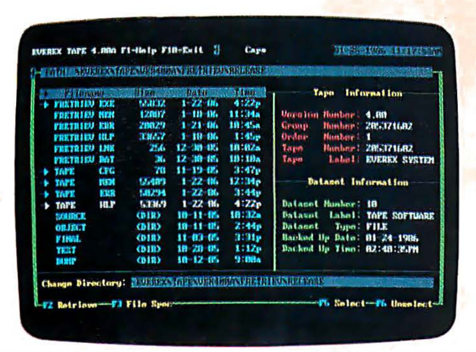


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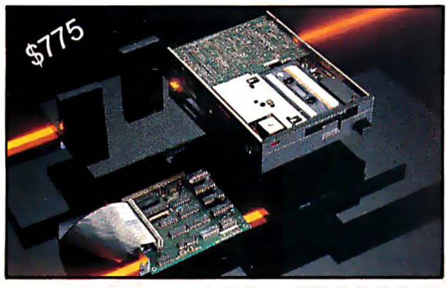
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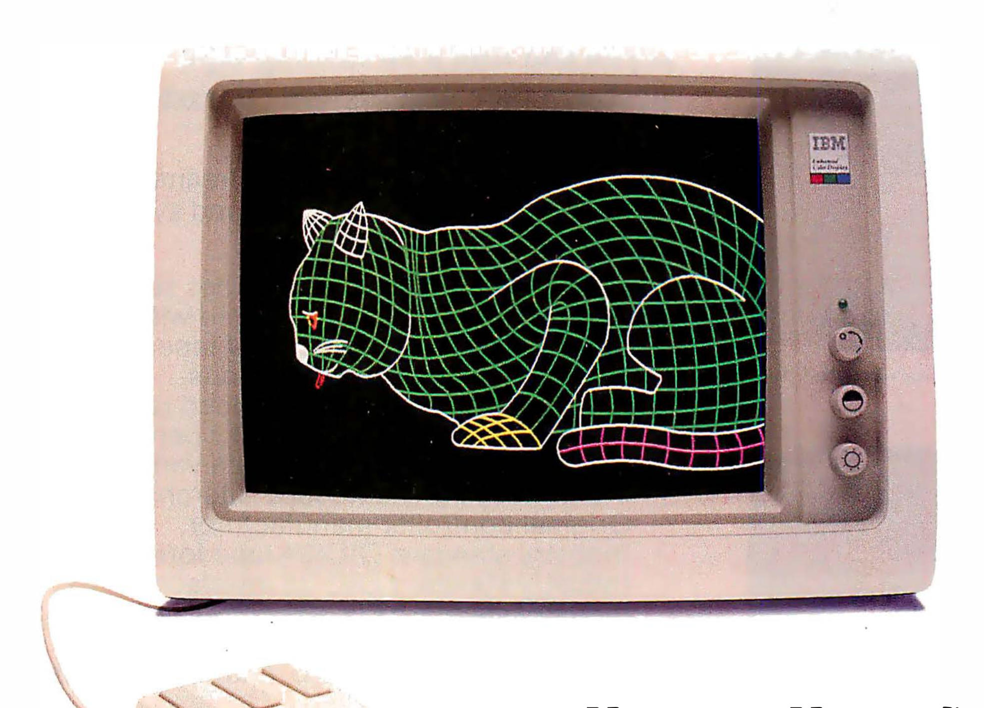


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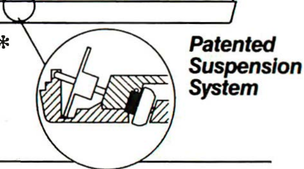


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PREDICTING INTERNATIONAL EVENTS

BY PHILIP A. SCHRODT

Using a Holland classifier to model political knowledge and make short-term forecasts

WHILE POLITICAL events occasionally appear random and capricious, to an expert politics is, for the most part, regular and predictable. Even though a single event may be devoid of practical consequences, foreign policy experts are able to see meaning in ordinary political behavior and accurately forecast its effects on international behavior. The existence of regularities in international behavior makes politics possible; it also makes feasible at least some formal modeling of political behavior.

REPRESENTING POLITICAL KNOWLEDGE

With the development of improved communications and computers in the 1950s, the prospect of systematically studying politics attracted a number of political scientists. Armed with statistical techniques borrowed from the life sciences and emboldened with the new computing technology that reduced months of manual statistical computations to hours, these researchers led the statistically oriented behavioral revolution and changed the face of political science.

The most conspicuous success of the behavioralist effort has been in the field of voting behavior, where advanced statistical and measurement techniques enable the prediction of elections. By questioning only a couple of thousand properly selected potential voters, we can predict the outcome of tens of millions of votes. Nowadays a politician would no sooner consider running a national campaign without survey research than he or she would consider using a Conestoga wagon as a primary means of transportation.

Some political behavior that can be described numerically—such as bureaucratic budgeting and international arms races (see Schrodt, 1982)—has been modeled with difference equations. And researchers have progressed in theoretical understanding of some political processes using models similar to those used in economics. Luterbacher and Ward (1985) provide a survey of the contemporary formal modeling effort in the international relations field.

Surveys, difference equations, and economics-based preference orderings are, in fact, forms of knowledge representation of political behavior. If you can predict an election using results of a 2000-person survey or predict an arms race by plugging a few numbers into the appropriate equations, you can represent political behavior in a compact form. With few exceptions, these representations are numerical and usually involve classical statistics and mathematics.

Political behavior, however, is often not easily understood through numerically oriented techniques. Here, political science differs substantially from economics, where almost all of the interesting variables are numerical. In retrospect, political science lacked a systematic means of dealing with rules: the specific conditional (if-then) statements about nonnumerical factors that appear to be regularly used in political decision making. Although behavioralists hoped to reduce this conditional information to a small number of numerical indicators—in the same manner that economic indicators such as unemployment rate, inflation rate, and GNP

(continued)

Philip A. Schrodt teaches mathematical modeling and international relations at Northwestern University. He can be contacted at the Department of Political Science, Northwestern University, Evanston, IL 60201.

characterize the overall state of an economy—or reduce political knowledge to a small number of categorical indicators, neither approach was universally successful.

AI APPROACHES

Around the beginning of the 1980s political scientists began to experiment with alternative models based on concurrent developments in artificial intelligence and expert systems. Spearheaded by work at MIT, Ohio State, and Syracuse, this effort has focused on two problems that had, for the most part, remained intractable to existing statistical techniques: the prediction of individual votes by a member of Congress and the short-term prediction of international events. By embodying political knowledge in a conditional rule base rather than in statistical distributions, algebraic equations, or preference orderings, a means of systematically studying political behavior gradually developed.

Aside from their intrinsic importance, these two problems have a couple of advantages. They are easily testable: congressional votes are known, and testimony relating to these votes is readily available; and accounts of day-to-day international events are available through historical and journalistic sources. More important, human experts can readily forecast these political behaviors. Lobbyists and congressional aides constantly calculate voting probabilities; international relations experts can usually make fairly precise short-term predictions. Since political predictions are indeed possible, surely we can at least approximate those and similar predictions using AI techniques.

The dominant cognitive mode of traditional international analysis involves a combination of analogy or pattern matching based on historical precedent and some general rules. The incidence of analogy as justification for policy actions is very high. For example, the analogical terms "Munich," "Vietnam," and "Pearl Harbor" are some of the most powerful constructs in the foreign policy lexicon of the United States. These analogies use a very large database of past events, and the acquisition of that database is a major part of the training of an expert. In hindsight, the use of these analogies may sometimes seem inappropriate or inconsistent, yet they are accurate with sufficient frequency to be effective in policy formulation.

Precedent is probably used in lieu of statistical knowledge because the international system is a *variable-rich but sample-poor* environment. The international system changes very slowly and hence provides little new information at any given time. The number of potential variables that are important is very large, and repeated experimentation is virtually impossible. Therefore, the number of occasions on which variables co-occur under a roughly similar set of conditions is

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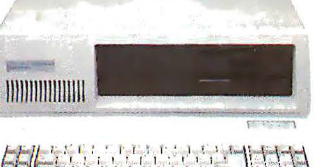
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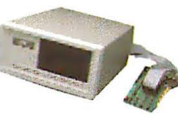
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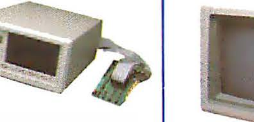


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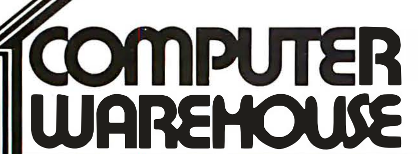
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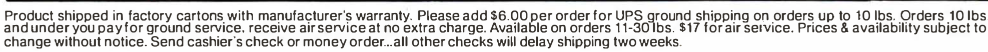
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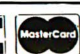
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limited. This complex, uncontrollable, unrepeatable nature of international events means that statistical methods requiring large sample sizes, controlled conditions, or random sampling techniques cannot be used in this task. Analogy and pattern matching seem to fill the gap.

In addition to analogy, other considerations are important. These include, for example, various commonsense rules of inference, knowledge of how the resources available to a nation constrain its scope of action, and knowledge of the existing policies of a state. In many cases, repeated patterns of behavior imply certain knowledge. For example, while large states sometimes invade small states, small states almost never invade large states. Thus, in attempting to duplicate political expertise, a plausible starting point is to look for historically based rules and pattern matching.

Holland Classifiers

Over the past year I've used a learning system called the Holland classifier to model a simple but real problem of short-term international behavior prediction. Simply put, a Holland classifier solves classification problems; that is, it takes a set of attributes about a situation and classifies that situation into one of a number of discrete categories. If used in a medical expert system, for example, a Holland classifier would accept a large number of characteristics about a patient (including symptoms, results of medical tests, reactions to medications, and so forth) and on the basis of this information classify the patient into a disease and treatment category.

In the general scheme I'm using, the Holland classifier has three components: messages, a "bulletin board," and a rule base. Messages posted on the bulletin board describe the situation. The rules then scan the bulletin board for messages that match the classifier of the rule. If there are matches, the rule "bids" for the right to replace that message with the rule's result. Bids are based on the strength of the rule and the specificity of the match. The highest-bidding

(continued)

A Holland classifier is totally self-organizing and extremely flexible.

rule gets to replace the message. It then pays the bid to the rule that posted the message it responded to.

This process (summarized in listing 1) continues until a terminal message is posted, which becomes the classification. The system rewards the rule posting the terminal message with a payoff. This payoff is positive if the terminal message is the correct classification (based on some evaluation function); it is negative if the classification is incorrect.

Rules in the Holland system consist, then, of three parts: classifier, result, and strength. Like messages, the classifier and the result are simple strings of characters; the strength is represented by a number. Rules are, in effect, IF. . .THEN statements similar to those used in expert systems: The classifier is the antecedent, and the result is the consequent.

In Holland's scheme, the characters that represent the classifier and the result come from an alphabet that has only three values:

0 Feature is absent.
* Pass-through: Feature may be present or absent.
1 Feature is present.

When a pass-through value occurs in a result, the value encountered in the message that was matched is substituted for the pass-through character. Thus, messages contain only {0,1} characters.

The process of competitive bidding and payoffs for posting terminal messages ensures that the rules that have been most successful in posting useful messages in the past are most likely to be successful in the future. Rules that post meaningless or incorrect messages diminish in strength so that they are less likely to succeed in

(continued)

Listing 1: *The Holland classifier main evaluation loop. The loop is continued until one of the following three conditions has been met: (1) There are no messages left on the board; (2) All bids for rules are below a set threshold (none of the rules match the messages particularly well); (3) The loop has been repeated more than a set number of times. This rule prevents infinite looping due to recursive parasitic rules whose classifiers match their own output messages.*

```
Loop
With each message do
  With each rule do
    1. Compute Match(Rule, Message)
    2. Compute
         Bid=Match*Strength*Bid_Weight
    3. If Bid>Highest Bid for Message
         Then Replace Bid_Winner with Rule
  End_With {rule}
  With Bid_Winner do
    1. Subtract Bid from Strength
    2. Add Bid to Strength of Rule which posted
         Message
    3. If Bid_Winner's Result is a Prediction
         Then
           1. Compute Payoff by comparing prediction to actual events.
           2. Add Payoff to Strength
           3. Remove Message from Board
         Else
           1. Replace Message with Result on Board
  End_With { Bid_Winner }
End_With {message}
End_Loop
```

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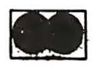
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the future. This modification of strength allows the system to learn.

Although a Holland classifier usually requires a large number of trials to attain efficient performance, it has the advantage of being totally self-organizing and extremely flexible. Like natural problem-solving systems—the brain and DNA—a Holland classifier is very robust. Because the "knowledge" in the system is spread over a number of rules, the failure of one or two rules due to a change in the system is unlikely to have much effect on the overall behavior. Another advantage of the system is that while parts of it are intrinsically parallel (in principle, at least, all rules could scan the message board simultaneously), it is sufficiently simple that it can be implemented efficiently on a serial system—even on a microcomputer.

PREDICTING WITH A HOLLAND CLASSIFIER

The work I have done uses international relations "events data" to approximate international behavior. In its most basic form, events data summarizes the daily interactions between nations. The summaries use four variables: date, actor nation, event, and target nation.

For example, to summarize that on May 28, 1986, the United States (actor) protested (event) the Soviet Union's (target) behavior during the Chernobyl nuclear accident, you would code:

860528 002 09 365

In this example, 002 and 365 are standard codes for the United States and the Soviet Union, respectively; 860528 is the date, and 09 is an event code indicating a protest. (For more information on events data, see the *International Studies Quarterly* issue cited in the Bibliography.)

While a single event carries very little information about the relations between two nations, using events gathered over a long period of time, you can ascertain distinctive patterns of interactions. The use of events data sacrifices short-term detail to facilitate coding and statistical analysis and then reestablishes detail by looking at thousands of events.

In my experiments, I have used the Conflict and Peace Data Bank (COPDAB) events data set collected by Edward Azar and Thomas Sloan and provided through the Inter-University Consortium for Political and Social Research at the University of Michigan. The COPDAB set uses only 15 codes, ranging from 01 for international unification to 15 for violent conflict such as war. To get the highest density (events per day) of data, I focused on events between the United States and three European nations: the United Kingdom, France, and West Germany. COPDAB covers the period 1948–1978. I analyzed events nondirectionally; for example, the U.S./U.K. data set includes events in which the U.S. was actor and the U.K. was target as well as events in which the U.K. was actor and the U.S. was target. I coded data only for occurrence, not frequency, so that each of five instances of an event code 07 appeared the same as one instance. You could, however, expand the system to use frequencies.

I used the COPDAB data to generate a large number of event "archives." An archive is the set of events that occurred in a time period. In the experiments, each prediction problem is created by choosing a random date T and then coding the following archives:

Input messages: [T−1 to T−10]
[T−11 to T−20]
[T−21 to T−30]
[T−31 to T−40]

Output occurrence: [T to T+20]

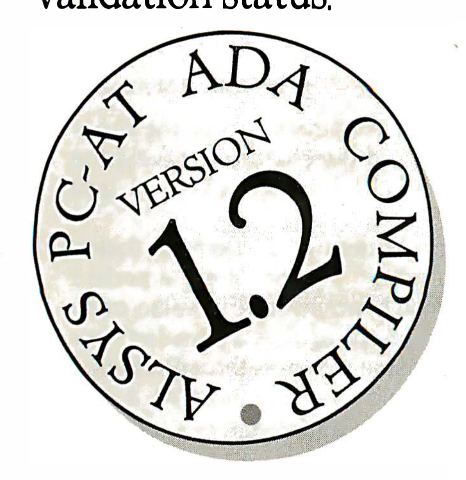
The specific coding I used allocated 16 bits to the events and 4 bits for the lag. For example, if only interactions of types 07 and 08 occurred during the period 11 and 20 days prior to the date, that archive would be coded 00000011000000000010.

This gives a surplus of at least 2 bits (and actually more, as event types 1, 14, and 15 aren't found in this data), which the system could use to identify intermediate rules. While these archives consist primarily of cooperative events, they show quite a bit of variety and there are no obvious ways

(continued)

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to produce accurate predictions.

The initial rules in the system were generated by reading a random set of data records, randomly choosing one of the input archives as the classifier and the output archive as the message. Both parts of the rule were then randomly mutated with a fixed probability, called Mutation_Probability, by changing some of the feature-absent and feature-present characters to the pass-through character. This captures, in a very primitive fashion, the process of precedent-based prediction: The initial rules are based directly on earlier observed events with some random modification. Actual human learning is, of course, far more systematic and involves teaching carefully chosen examples of characteristic behavior rather than random examples, but this approximation allows my system to be totally self-organizing. The input archives, with information identifying their time lag (0, 10, 20, or 30 days), are posted on the bulletin board of the classifier, and the payoff is computed based on a measure of difference between the prediction produced by the classifier and the actual outcome occurrence.

Rules match posted messages using a simple comparison of the features of the classifier and the message. I defined a match simply as

$$\text{Match} = 40 - \Sigma_i \,|\,\text{Classifier}_i - \text{Message}_i\,|$$

with the summation over the event types, and the characters having the numerical values of 0 = 0, * = 1, and 1 = 2.

Consequently, a perfect match would have a value of 40; a perfect mismatch would have a value of 0, and a match against a classifier consisting solely of pass-through characters would have a value of 20. A rule may bid for a message provided the degree of match exceeds a level called Match_Minimum; this is a minor modification of Holland's scheme, which required perfect matches but didn't penalize pass-through codes. This is only a first approximation to a matching criterion and one chosen largely for computational efficiency; an obvious alternative measure would be a more complex pattern-match measure such as a Levenschtein metric.

A prediction—which is the terminal message in this system—is identified by coding 1111 as the final 4 bits of the message. The payoff function compares the output predicted in the message to the observed outcome. This function is similar to the match function except that it can take negative values:

$$\text{Payoff} = 20 - \Sigma_i \,|\text{Outcome}_i - \text{Message}_i|$$

The use of negative values means that if the prediction is particularly inaccurate, the payoff will be negative and decrease the strength of the rule that posted it.

Finally, to allow the system to recognize that it has not seen a situation before and respond by not making a prediction, the Match_Minimum is

(continued)

also used as a threshold for acceptable bids. If no rule can make a bid above the threshold, the system creates a new rule by randomly choosing one of the messages on the board (one of the actual antecedent archives), mutating it to include a few pass-through characters, then taking the actual outcome as a result. This new rule replaces the weakest existing rule in the set. This process guarantees that if the system encounters behavior it has not seen before, it will incorporate that new behavior into its rule base.

RESULTS

I implemented the Holland classifier in UCSD Pascal on an Apple II. The program involves about 1000 lines of code, around half of which deal with output and statistical monitoring routines. To limit the amount of run time to something reasonable, I used a set of only 32 rules; in almost all my experiments, strength concentrated in about eight or fewer rules. [*Editor's note:* HCLASS, *a* Turbo Pascal *translation of the program, is available on disk, on paper, and on* BIX; *see the insert card following page* 352. *Listings are also available on* BYTEnet; *see page* 4.]

Keep in mind that this classifier is a stochastic process and its performance must be measured statistically. Random behavior enters in because of random selection of the initial rule set, random sampling of the database, random mutations of the rules, and some randomness in the ordering of rules (if two rules make identical bids, the first bidder will win). Usually, the random variation of the performance of the classifier is tightly bound, but unusually high and low values occur occasionally.

To measure the prediction success, I computed a statistic (unoriginally called S) for the classifier and a variety of alternative estimators. S is equal to

$$\frac{\text{correct predictions} - \text{incorrect predictions}}{\text{total predictions}}$$

Here, S takes on values between −1.0 (all predictions incorrect) and 1.0 (all correct).

To ascertain whether the Holland classifier was doing anything other than simply making random predictions, I made comparisons with three other predictors: a random predictor based on the observed event frequency alone, a prediction that simply repeated the previous observed archive, and a statistically optimized predictor I labeled "Best." I computed the average value of S for 100 trials of the predictors, then for a summary statistic used the ratio of S for the classifier with S for the Best predictor:

$$R_{100} = (\text{average } S_{Holland})/(\text{average } S_{Best})$$

If R_{100} is greater than 1.0, the classifier is doing better than the statistically optimal predictor; if R_{100} is less than 1.0, it is doing worse. The overall performance of the classifier is summarized in figure 1, which shows the distribution of the value of R_{100} over about 200 runs of the classifier (involving about 500 hours of computation) with various parameter values. This distribution is more or less normal with a mean around 0.94. Similar ratios for the random and previous predictors to the Best predictor are about 0.88 and 0.85, respectively, so the Holland classifier is usually doing considerably better than these, particularly since figure 1 includes a number of experimental runs with parameters that produced low success.

The classifier has several free parameters, such as the amount of reward given, the probability of a 1 or 0 mutating to a pass-through character, and the minimum acceptable

(continued)

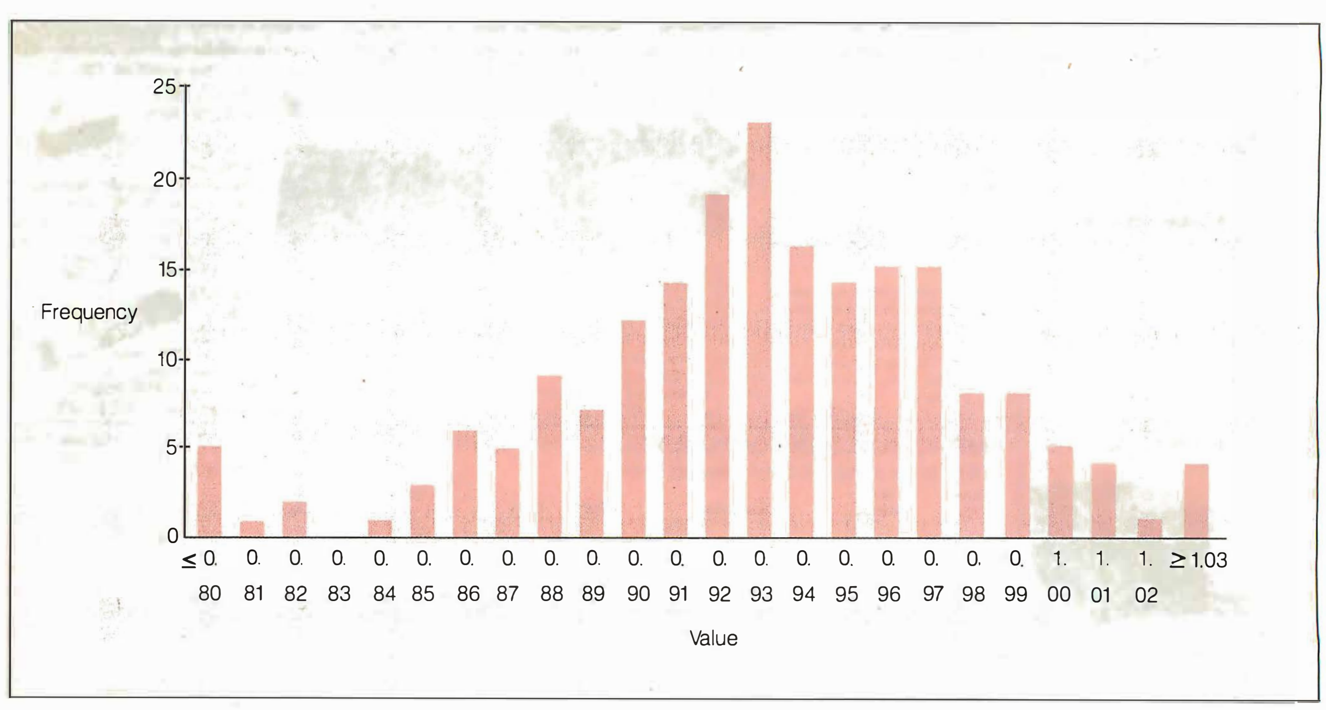


Figure 1: *The distribution of* R_{100} *over about* 200 *runs of the Holland classifier using various parameter values.*

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match. I experimented with a variety of values for these, but only the Mutation_Probability seems to have a consistent impact. With that parameter, higher mutation probabilities (30 to 40 percent) seem to produce better predictors than low mutation probabilities. Some fine-tuning in Match_Minimum is also needed. When a strict matching criterion (40 or 38) is used, rule replacement occurs with very high frequency: Few rules get an opportunity to build up any strength, and all rules are vulnerable to being wiped out in a replace operation when matches fail. Conversely, loosening the match criterion to 34 seems to allow too much flexibility and encourages random bidding. While I have not done sufficient experimenting to draw a firm conclusion on this issue, slight looseness on matching (one or two mismatches) seems best.

A key characteristic of most self-organizing systems based on John Holland's work is the use of "evolution" involving genetic-like mutation and recombination of rules. I have done some experimental work with the full Holland evolutionary system, but due to the length of time required for the programs to run, only a few sequences are available. Most of these exhibit a weak upward trend, though even this is very uneven and in some cases the performance of the classifier will rapidly deteriorate. It appears that you gain some predictive value from the evolutionary scheme but not a great deal and without a lot of consistency.

The weakness in the evolutionary system for this problem seems to lie in the lack of new input. Once a few strong rules are established, replacement of rules by outside data rarely occurs, and hence the only source of "innovation" is recombination and mutation. This means that the Holland predictions after, say, 1000 trials are still based on the original 32 samples while after about 200 samples the Best estimator has attained its asymptotic value and fluctuates only moderately around it. This genetic "aging" (or genetic drift, to use the more appropriate biological term) of some of the rule sets may account for the tendency to see long downward trends in some sequences. The obvious cure for this would be to allow the system to recognize when new rules should be brought in from the data to provide variability. The poor evolutionary performance may also be due to the original rule set being precedent-based and allowing for some rule replacement, so it is difficult to improve upon.

Optimistic Future

That the Holland classifier managed only a mean success of 94 percent of the statistically Best estimator was somewhat disappointing—I had hoped to do better. However, the

(continued)

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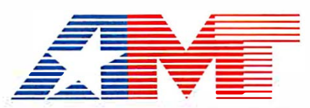
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I had to use calculus to figure out Best, but the Holland system did well on its own.

result is more impressive when you consider the following factors. First, the Holland success is far better than what would be produced by chance, almost never dropping to the level of the random and previous estimators, so the system is indeed learning. Second, the Holland estimator comes close to the Best estimator despite the fact that it has absolutely no information about what this optimal predictor is. In other words, I had to use calculus to figure out Best, but the Holland system was able to do almost as well (and, about 7 percent of the time, better) on its own.

Another problem with the test is that there was not a great deal of variability in the data, and hence a statistic predicting modal behavior (which Best did) was difficult to beat. However, during the process of debugging I discovered some circumstances where the Holland system would be better suited. Having cleverly turned off array bounds checking to save 10 percent on run times and then forgotten to initialize an index, I did about two days' worth of runs where the system roamed for hours through RAM reading data until it evoked some fatality in the operating system. Here, interestingly, the Holland estimator did considerably better than the Best estimator because, with rule replacement, it adapted fairly quickly to the changing data while Best was slower to respond. In these experiments, R_{100} values of 2.0 and greater were not uncommon. In a denser, more varied event data set, the Holland system would probably be far superior to the statistical techniques.

The system discussed here is only a first, highly simplified approximation to the knowledge base and learning techniques of a political expert. The system is not a Metternich nor anywhere close. But similar techniques used with a vastly larger and more detailed database of past political behavior and probably with some systematic training by human experts (as is now done with some advanced chess-playing programs) could well be capable of predicting many political situations at least as accurately as a human expert.

A computer-based knowledge system would be useful in at least two ways. First, a machine can process large amounts of new information more rapidly than a human can, so that it could presumably master, for example, the complex internal politics of a new governing political party based on historical data more quickly than a human analyst could. Second, the machine is insensitive to the tendency of human decision makers to ignore precedents that point to undesired outcomes and would at least call these to the attention of the experts. Moreover, AI-based techniques such as the Holland classifier and rule-based systems are expanding the ways we have available of representing political knowledge and may, in the long run, lead to techniques as profound in their impact on the practice of politics as survey research. ■

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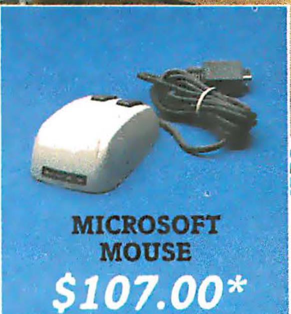
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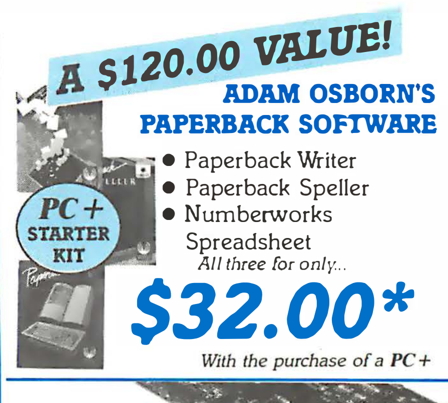
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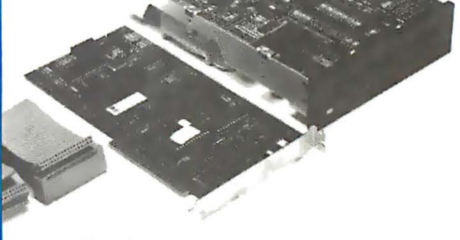


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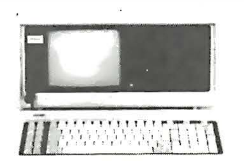


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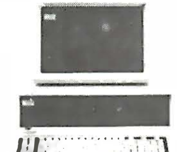
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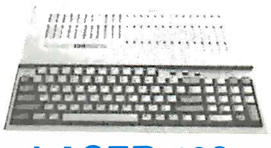
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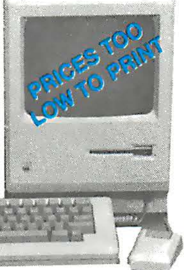


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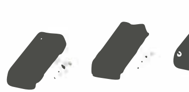
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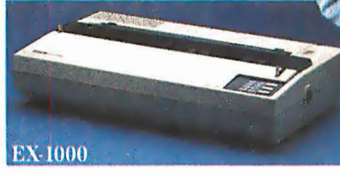
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HANDLING CONFLICTS IN DATA

BY CLARA Y. CUADRADO AND JOHN L. CUADRADO

A decision support system in Prolog

ONE OF THE major research areas of artificial intelligence concerns the representation and maintenance of knowledge. A problem of first-generation expert systems is that they cannot handle perturbation of their knowledge bases. Since in reality it is virtually impossible for us to provide exactly the right amount of knowledge and information to achieve our goals, we must be able to reason with incomplete and inconsistent knowledge and handle the removal or change of portions of the knowledge base. In drawing inferences from incomplete or inconsistent data, AI systems must be able to make choices among plausible alternatives and, if necessary, retract the inferences, undo the effects, and make new choices based on revised beliefs or new evidence. A related problem is carrying out deductions based on different beliefs and multiple sets of criteria.

Thus, an important component of state-of-the-art inference systems is a belief/evidence/truth maintenance subsystem. The responsibilities of such a subsystem include the accumulation of supporting evidence for each major deduction that the system carries out and the provision of mechanisms for the propagation of automatic maintenance of such sets of supporting evidence. Today there are many competing approaches to achieving these goals. (See references 1, 2, 3, and 4.)

In this article we will illustrate the knowledge representation and belief maintenance functions via a simple decision support system that has two major capabilities. First, based on incomplete or inconsistent data, the system may reach certain conclusions. When information is added or deleted, the deductions are adjusted or retracted, which entails forward and backward evidence propagation. Second, the system provides for "what if" analysis capabilities. We can make certain assumptions, let the system make deductions based on them, then withdraw a set of the assumptions and bring the system back to a consistent state. The system presented is implemented in Prolog. For a short introduction to how Prolog works, see reference 5.

To facilitate understanding, we have chosen an area of application that is both relevant and self-explanatory. Our example is based on a fictitious situation where personnel selection is supported by different individuals' beliefs about such "hard" evidence as technical competence relative to a specific project and such "soft" factors as interpersonal relationships. As it is, this simple decision support model can be used in any level of the control hierarchy of a corporation. It can also be expanded to help develop management strategies or to aid crisis management. The ideas illustrated here, however, are generic and can be used in any domain.

A DECISION SUPPORT EXAMPLE

One of the most frustrating duties of corporate managers is dealing with in-

(continued)

Clara Y. Cuadrado and John L. Cuadrado (Octy Inc., 10920 Oxford Court, Fairfax Station, VA 22039) both earned Ph.D.s from the University of Illinois at Urbana-Champaign. They taught at the University of Maryland and Dartmouth College, respectively, and now run their own company developing AI systems.

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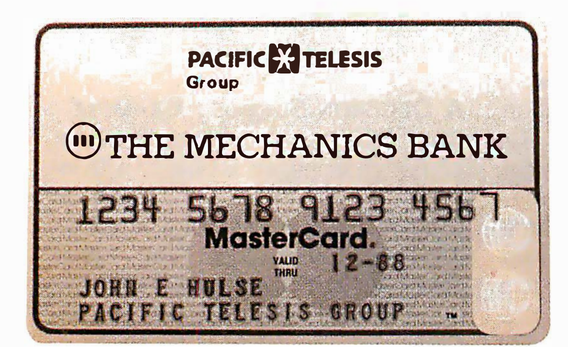
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terpersonal conflicts in their organization. While most experienced managers will tell you that interpersonal relationships greatly impact the structure and the efficiency of an organization, somehow the illusive quality of these relationships prevents them from becoming an acknowledged factor in a formal decision-making process. This is not difficult to understand; interpersonal relationships are complex, tenuous, and unstable. They are often difficult to detect and even more difficult to describe. Rumors and whispers in the office, "gut feelings," and "vibes" are not the kind of stuff our traditional corporate decision-making process is made of.

We will demonstrate our system with a fictitious case. Let's say that a middle-level manager, Mike, has a project that requires two engineers to work closely to develop a new design. He has four possible candidates: Alan, Bob, Charlie, and Dan. Assuming for now that all other qualifications of these candidates are irrelevant (we will introduce an important qualification later), we want to help Mike make his choice of a team based solely on one criterion: that the two individuals be able to work well together.

We know a few things about this selection process: First, Mike decides that he wants to be open-minded about the selection and therefore asks each of the four candidates to state his belief as to whether they can work with each other. Mike will try to base his decision on the mutual evaluation of his subordinates. For simplicity and clarity, in our example we allow the candidates to say only "yes," "no," or "don't know" to straightforward questions such as "Do you think you can work well with Dan?" "Do you believe Dan will be able to work well with Charlie?" We do not ask them to supply weights to their beliefs, nor do we consider the reasons for their answers.

In a more complex decision support system, naturally, all these weights to answers would be included. The individuals' justifications would consist of hard facts as well as less tangible evidence. The point is, the evidential hierarchy can be made arbitrarily deep and complex, but then at some point computational requirements for the system become an important consideration, a consideration beyond the scope of this article.

Next, Mike gives us a ranking of his opinion of the judgment of the four subordinates. He also supplies us with weights and justifications for his belief in the judgment of his subordinates, which we summarize in table 1. As we can see, Mike values Bob's opinion a great deal, not only because Bob is a good judge of character and always tells the truth but also because Bob knows the other three better than Mike himself. For this reason, Mike has assigned a "3" for his own judgment on the compatibility issue.

After Mike makes his choice of the engineering team based on compati-

(continued)

A selection can be made by combining the compatibility and competence analyses.

bility, he will present his decision to his boss, Penelope. Penelope has the final say on the selection of the team, and she wants to be able to play "what if" games to see what the results will be when changes are made in the assumptions. For example, because Dan is a new employee, the others have little to go on in judging whether he can work well with a particular colleague. Penelope may test out several assumptions. In one scenario she may make Dan a Mr. Congeniality, and in another she may make him Enemy-of-the-People. In this way, she can get a feel of the impact Dan's personality may have on Mike's group.

Penelope also has considerations other than personal compatibility in mind. She calls in Jack, the chief scientist of her division, and asks him to rate the four candidates on the basis of their respective technical competence. The list Jack gives her is summarized in table 2.

Penelope wants to combine Mike's compatibility analysis and Jack's technical competence analysis to arrive at a reasonable selection of the team. She first obtains a list of qualified teams that have a compatibility rating of, say, 3 or above. Then she ranks these eligible teams according to their technical competence (based on Jack's beliefs) and picks the team with the highest technical rating. Here, for illustrative purposes, we chose to use a naive rule of combination. A more sophisticated approach such as the Dempster-Shafer mathematical evidential theory (see reference 6) should be incorporated in an industrial-strength system.

In this manner, Penelope knows she

(continued)

Table 1: *Mike's ranking of the judgment of the four subordinates.*

Name of Employee	Weights (5: most credible, 0: least credible)	Justification
Bob	4	Good judgment, intuition; always says what he means.
Charlie	3	Observant, reliable.
Dan	2	New employee, can't quite judge others' relations yet; seems smart and trustworthy.
Alan	1	Tends to be opinionated, emotional; distorts facts occasionally.
Mike	3	Manager; does not know the others very well on a personal level.

Table 2: *Jack's ranking of the technical competence of the four subordinates.*

Name of Employee	Weights (5: best 0: worst)	Justification
Dan	5	Recent Ph.D.; has excellent new ideas.
Bob	3	Good command of general knowledge.
Alan	4	Veteran engineer; very experienced.
Charlie	2	Skills somewhat outdated.

Listing 1: *The Decision Support System program illustrates the flexibility of a simple knowledge representation and belief maintenance system. In walking through the Prolog code, the comments are enclosed in /* */ pairs (for general comments) or preceded by a % (for clarifying specific functions of the code).*

```
%   The various possible teams are:

teams([team(charlie,bob),team(charlie,alan),
       team(charlie,dan),team(bob,alan),
       team(bob,dan),team(alan,dan)]).

% Mike's opinions are:
mike(credibility(assumption,3),[opinion],[]).
mike(credibility(bob,4),[opinion],[]).
mike(credibility(charlie,3),[opinion],[]).
mike(credibility(dan,2),[opinion],[]).
mike(credibility(alan,1),[opinion],[]).

% Jack's opinions are:
jack(technical_competence(assumption,3),[opinion],[]).
jack(technical_competence(dan,5),[opinion],[]).
jack(technical_competence(alan,4),[opinion],[]).
jack(technical_competence(bob,3),[opinion],[]).
jack(technical_competence(charlie,2),[opinion],[]).

% Bob's opinions are:
bob(can_work_with(no,bob,alan),[opinion],[]).
bob(can_work_with(yes,bob,charlie),[opinion],[]).
bob(can_work_with(yes,bob,dan),[opinion],[]).
bob(can_work_with(no,alan,charlie),[opinion],[]).
bob(can_work_with(yes,charlie,dan),[opinion],[]).

% Alan's opinions are:
alan(can_work_with(yes,alan,bob),[opinion],[]).
alan(can_work_with(yes,alan,charlie),[opinion],[]).
alan(can_work_with(yes,bob,charlie),[opinion],[]).

% Charlie's opinions are:
charlie(can_work_with(yes,charlie,alan),[opinion],[]).
charlie(can_work_with(yes,alan,charlie),[opinion],[]).
charlie(can_work_with(yes,charlie,bob),[opinion],[]).
charlie(can_work_with(yes,bob,charlie),[opinion],[]).

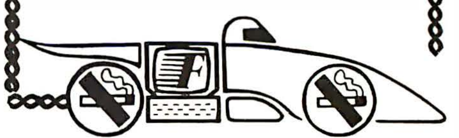
% Dan's opinions are:
dan(can_work_with(yes,dan,alan),[opinion],[]).
dan(can_work_with(yes,dan,bob),[opinion],[]).
dan(can_work_with(yes,dan,charlie),[opinion],[]).
dan(can_work_with(yes,alan,charlie),[opinion],[]).
dan(can_work_with(no,alan,bob),[opinion],[]).

/* The main predicate of the system is "decide."
This is what a top-level manager, like Penelope in
our story, would use to produce rankings for each
of the possible teams for a given project.
*/

decide :-
       evaluate(mike,[bob,charlie,alan,dan]),
       % generate Mike's view
       rank_teams(Rankings),
       eligible(Rankings,Eligible),
       % determine eligible teams
       sortem(Eligible,Sorted),
       cls,
       report_ranks(Sorted),
       nl.

%   The "eligible" predicate is a filter that applies a
%   threshold criterion to each of the possible teams.
```

(continued)



```
%   It discards those teams whose compatibility is below
%   the given threshold (specified as 3 in this case).
eligible([],[]).
eligible([team(P1,P2,R1,R2)|Teams],[team(P1,P2,R1,R2)|Es]) :-
      R1 >= 3,
      % teams with Compatibility 3 or higher are OK
      eligible(Teams,Es).
eligible([_|Teams],Es) :-
% teams with low Compatibility we discard
      eligible(Teams,Es).


%  the "rank_teams" predicate produces rankings for each
%  of the teams based on both compatibility (according
%  to Mike) and competence (according to Jack).
rank_teams(Rankings) :-
      cls, write('Please wait while')
           write('eligible teams are ranked.'),
      teams(Teams),
% fetch the possible teams from the database
      rankem(Teams,Rankings).

rankem([],[]).
rankem([team(P1,P2)|Teams],[team(P1,P2,R1,R2)|Rankings]) :-
      assess_compatibility(mike,P1,P2,R1),
      assess_competence(jack,P1,P2,R2),
      rankem(Teams,Rankings).

report_ranks([]).
report_ranks([team(P1,P2,R1,R2)|Teams]) :-
      report_ranking(P1,P2,R1,R2),
      report_ranks(Teams).

report_ranking(P1,P2,R1,R2) :-
      nl,write('for the team of '),write(P1),
      write(' and '),write(P2),nl,
      write('compatibility (according to '),
      write('Mike) --> '),write(R1),
      write('   competence (according to '),
      write('Jack) --> '),write(R2),nl.

assess_competence(View,P1,P2,R) :-
      V1 =.. [jack,technical_competence(P1,R1),_,_],
      V1,
      V2 =.. [jack,technical_competence(P2,R2),_,_],
      V2,
      R is R1 + R2.

% We do not assume that the compatibility relation
% "can_work_with" is symmetric. That is, it may be
% possible to have "can_work_with(yes,bob,charlie)"
% and yet also have "can_work_with(no,charlie,bob)"
% Therefore, in assessing compatibility we look at
% the relation going both ways and then take an average.
assess_compatibility(View,P1,P2,R) :-
      assessment(View,P1,P2,R12),
      assessment(View,P2,P1,R21),
      R is (R12+R21)//2.

assessment(View,P1,P2,Result) :-
      rank(View,can_work_with(yes,P1,P2),Yes),
      rank(View,can_work_with(no,P1,P2),No),
      Result is Yes - No.

rank(View,Predicate,Rank) :-
      V =.. [View,Predicate,Sby,_],
      V,
      analyze(View,Sby,Rank).
rank(_,_,0).
```

(continued)

```
analyze(_,[],0).
analyze(View,[Sby|Sbys],I) :-
      V =.. [View,credibility(Sby,W),_,_],
      V,
      analyze(View,Sbys,I1),
      I is I1 + W.


/*   Typical output for the "decide" predicate,
when run with the database of workers' opinions
about their mutual compatibility and their managers'
evaluations, is as follows:
for the team of bob and dan
compatibility (according to Mike) --> 3
competence (according to Jack) --> 8

for the team of charlie and dan
compatibility (according to Mike) --> 3
competence (according to Jack) --> 7

for the team of charlie and bob
compatibility (according to Mike) --> 5
competence (according to Jack) --> 5
*/
/*  Predicates to propagate "new" information
*/
%  The "evaluate" predicate cycles through a list
%  of Persons and ascertains their opinion on the
%  compatibility of the various workers. It installs
%  these views in the View frame.
evaluate(View,Persons) :-cis, write('Please wait for
propagation of information.'), inv(View,Persons,Persons).

inv(_,[],_).
inv(V,[P|Ps],Persons) :-
      inv1(V,P,Persons),
      inv(V,Ps,Persons).

inv1(V,_,[]).
inv1(V,P,[P|Ps]) :-
      inv1(V,P,Ps).
inv1(V,P,[PP|Ps]) :-
      explore(V,P,PP,[bob,charlie,alan,dan]),
      inv1(V,P,Ps).

%  The "explore" predicate determines who can work
%  with whom and propagates this information both
%  forward and backward. That is, for a given pair
%  of individuals it determines whether they can
%  work together according to the various Views and
%  for each of these views it manages both the
%  Supported_by and the Supports slots for the
%  "can_work_with" relation.
explore(View,P1,P2,Views) :-
      gather_evidence(View,can_work_with(yes,P1,P2),Views),
      gather_evidence(View,can_work_with(no,P1,P2),Views),
      assessment(View,P1,P2,Result).

gather_evidence(Checker,Predicate,Views) :-
      checkem(Checker,Predicate,Views).

checkem(_,_,[]).
checkem(Checker,Predicate,[V|Vs]) :-
      check(Checker,V,Predicate),
      checkem(Checker,Predicate,Vs).

check(Checker,View,Pred) :-
      V =.. [View,Pred,Sby,S],
      retract(V),
      update_view(View,Pred,Sby,Checker,S),
      % adjust what View supports
```

```
      update_checker(Checker,View,Pred).
      % adjust what Checker is supported_by
check(_,_,_).
% this View does not support this Pred, no harm done.

% Update the Support set for this Pred in this View
update_view(View,Pred,Sby,Checker,S) :-
      member(Checker,S),
      % if already in Support set don't add it again
      V =.. [View,Pred,Sby,S],
      assert(V).
update_view(View,Pred,Sby,Checker,S) :-
      V =.. [View,Pred,Sby,[Checker|S]],
      assert(V).

% Update the Supported_by set for this Pred in this View
update_checker(Checker,View,Pred) :-
      C =.. [Checker,Pred,Sby,S],
      retract(C),
      % is Pred already supported_by other views?
      (member(View,Sby),
      % is this View already recorded?
      assert(C)
      % yes, don't include again
      ;
       New_C =.. [Checker,Pred,[View|Sby],S],
      assert(New_C)
      ).
update_checker(Checker,View,Pred) :-
% Pred not supported by any
      C =.. [Checker,Pred,[View],[]],
      % other views so far
      assert(C).
%  The "assume" predicate is used in "what if"
%  processing. That is, the user can add
%  assumptions at any level and they will be
%  propagated through the system.  For example,
%  Mike might find there is no information on
%  the compatibility of Alan and Dan. He can
%  then assume that is true:
%  assume(mike,can_work_with(yes,alan,dan))
%  and run the system to see what impact this
%  has on the team rankings.
assume(View,Pred) :-
      update_checker(View,assumption,Pred).

/*  Predicates to withdraw information
*/
% The "remove" predicate retracts Pred from the
% given View. It also adjusts the Supported_by
% set and the Supports set. It is used primarily
% in "what if" processing.  For example, Mike might
% decide to discard Charlie's opinion on the
% compatibility of Bob and Dan.  He can do this
% by issuing the command:
% remove(charlie,can_work_with(yes,bob,dan))
% and then run the system to see the impact on the
% team rankings.
remove(View,Pred) :-
      V =.. [View,Pred,Sby,S],
      retract(V),
      adjust_Sby(View,Pred,Sby),
      adjust_S(View,Pred,S).

adjust_Sby(_,_,[]).
adjust_Sby(View,Pred,[assumption|Sbys]) :-
% if it was an assumption
      adjust_Sby(View,Pred,Sbys).
      % there nothing to go back to
adjust_Sby(View,Pred,[Sby|Sbys]) :-
```

(continued)

The system lets you adjust to changing situations should new information become available.

can make a reasonably good choice because all her subordinates have had some appropriate input in the selection process and she has taken into consideration both the compatibility and competence criteria. What is more, she knows that she can adjust to changing situations quickly and logically should new information become available. For instance, if at a certain point of the project previous experience becomes significantly more important than innovation, she can raise Alan's competence weight over Dan's and run the systems through to see if the team will do better with Alan. Again, Alan's compatibility rating will be considered along with his competence rating.

THE IMPLEMENTED SYSTEM

The Decision Support System program in listing 1 implements the simple belief maintenance system discussed above. [*Editor's note: The Prolog source code for the Decision Support System is available on disk, in print, and on BIX; see the insert card following page 352 for details. It is also available on BYTEnet; see page 4. The source code, in Arity Prolog, is compatible with any Prolog that supports Clocksin and Mellish's full standard (reference 7).*] The system illustrates the representation of inconsistent and incomplete knowledge as well as the propagation of beliefs through the various levels of the system.

The first part of the program consists of the database as described in the body of this article, which can be changed and experimented with easily. Next come the main driver of the program and the predicates used to propagate the addition and removal of information up and down the

(continued)

```
        V =.. [Sby,Pred,SSby,S],
        retract(V),
        efface(View,S,New_S),
        VV =.. [Sby,Pred,SSby,New_S],
        assert(VV),
        adjust_Sby(View,Pred,Sbys).

adjust_S(_,_,[]).
adjust_S(View,Pred,[S|Ss]) :-
        V =.. [S,Pred,Sby,SS],
        retract(V),
        efface(View,Sby,New_Sby),
        check_empty_Sby(S,Pred,New_Sby,SS),
        adjust_S(View,Pred,Ss).

% If Pred no longer has any Support under this
% view then we had better adjust all other things
% that depend on it
check_empty_Sby(View,Pred,[],S) :-
        adjust_S(View,Pred,S).
check_empty_Sby(View,Pred,Sby,S) :-
% we still have a non-empty Sby
        V =.. [View,Pred,Sby,S],
        % so  no problem upstream
        assert(V).

/* Utilities
*/
% pretty print a Predicate according to a certain View
ppr(View,Predicate/Arity) :-
        functor(F,Predicate,Arity),
        V =.. [View,F,Sby,S],
        V,
        nl, write(F),
        nl,tab(5),write('Supported_by: '),write(Sby),
        nl,tab(5),write('Supports: '),write(S),nl,
        fail.
ppr(_,_).

% remove the first occurrence of an element from a list
efface(A,[A],[]) :- !.
efface(A,[A|L],L) :- !.
efface(A,[B|L],[B|M]) :- efface(A,L,M).
member(X,[X|_]).
member(X,[_|Y]) :- member(X,Y).

% do quicksort
sortem(List,Result) :- qsort(List,Result,[]).

qsort([H|T],S,X) :-
        split(H,T,A,B),
        qsort(A,S,[H|Y]),
        qsort(B,Y,X).
qsort([],X,X).

split(H,[A|X],[A|Y],Z) :-
        order(A,H),
        split(H,X,Y,Z).
split(H,[A|X],Y,[A|Z]) :-
        split(H,X,Y,Z).
split(_,[],[],[]).

order(team(_,_,_,A),team(_,_,_,B)) :-
        A > B.

/*  End of program.  */
```

hierarchy. Utility predicates are also included.

In the database the general scheme for storing predicates under a given view is as follows:

<view> (<predicate>(. . . <arg-list> . . .), <supported__by>,<supports<)

where "supported__by" and "supports" are lists that refer to other views which support this predicate and which this predicate supports, respectively.

Note that we include the credibility and technical competence factors under Mike's and Jack's views, rather than making them stand-alone facts. In this way it is possible to use the "what if" mechanism (provided by the "assume" and "remove" predicates) to try various scenarios in which the factors can be changed and their effects on the team rankings determined.

SUMMARY

As we progress deeper into the information age, it becomes increasingly obvious that, in any decision-making process, what we need is not just more information but more intelligent techniques to obtain better, more pertinent, and accurate information. With artificial intelligence techniques, information processing can be augmented with capabilities to deal with incompleteness, inconsistency, uncertainty, different beliefs, views, and attitudes. ■

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A simple program that demonstrates the deductive power of Prolog

ARTIFICIAL INTELLIGENCE is a growing science, and the present literature refers more frequently to real-world problems and less to the domain of games. However, many logic puzzles or games can still be used for illustrative purposes. In this article, we present Watson, a Prolog program for an n-person, zero-sum game with imperfect information, based on the game CLUEDO. [*Editor's note*: CLUEDO *is a registered trademark of* J. *Waddington*.]

CLUEDO uses an unusual set of playing cards that evokes the context of a detective investigating a crime. The game has three kinds of cards: suspects (potential murderers), locations (places where a murder might have been committed), and weapons (murder weapons).

When preparing to play the game, a referee draws, in a random fashion, one card of each type from the complete deck. During the game these three cards, which define the murderer, the location, and the weapon used, are kept in a box controlled by the referee. The remaining cards are divided at random among the competitors. Players then take turns, and each player has two options: question the next player or formulate an accusation.

A question has a fixed structure and is composed of the names of one suspect, one location, and one weapon. If the player addressed has some of the named cards, that player must show one of these to the questioner (and only the questioner). If the player addressed has none of the named cards, the questioner will address the next player, and so on, until one card has been shown to the original questioner or until all of the players have been addressed.

At this point, the active player may also formulate an accusation by naming a suspect, a location, and a weapon card. The referee checks the accusation against the cards hidden in the box. If the accusation proves to be completely correct, the player has won the game. If the accusation contains a fault, the player is eliminated; however, the player will continue to answer the questions of the other players.

PROBLEM CHARACTERISTICS

In a game like CLUEDO, players have to cope with three very distinct problems. The first is keeping track of the partial knowledge that emerges during the game. Each player has to remember this information in a suitable form for future use. The second problem is deciding which questions should be asked to solve the crime as soon as possible. The third problem is exploiting the information available, to decide whether an accusation can be safely formulated.

Generally, players deal with problems two and three by building hypotheses, checking them against facts to validate or invalidate them, and building new hypotheses. Programming such a strategy with a procedural programming language would require significant effort to administer the tree of hypotheses and their validation status. In Prolog, however, the hypotheses are handled automatically by the backtracking mechanism. The program has only to manage the monotonically increasing knowledge of proven facts.

The Prolog program Watson simulates the reasoning of a CLUEDO player and could be used for giving advice to one of the players. The pro-

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gram not only has to answer questions by combining known facts, but it also has to generate the best questions for the player to ask to improve his or her position.

Similar situations exist in many expert systems that interact with humans, such as diagnostic systems. To have an efficient dialog the expert system must select the next question carefully in order to converge most rapidly upon the solution.

A possible extension to Watson would be to create various versions that compete with each other, possibly with one human player.

Our primary purpose here is to demonstrate the use of Prolog for such a project. In doing so, we'll use the Prolog syntax of W. F. Clocksin and C. S. Mellish from their book, *Programming in Prolog* (Springer-Verlag, 1981), to develop a simple program. Interested readers can add embellishments to the user interface, change the number of players, introduce more elaborate strategies, or create versions for different implementations of Prolog. For those interested in a complete program with user interface, we have developed a version of Watson in micro-PROLOG 1.21.

The Knowledge Base

The knowledge base for our program has to hold game-independent and game-dependent knowledge. Game-independent knowledge includes definitions of the elements of the game, their constraints, and the strategic rules that must be applied to win. Game-dependent knowledge includes the facts that emerge during the current game.

To begin with, the knowledge base holds facts about the names of the players. For now, we simply call them p1, p2, and p3. By convention, p1 is the program itself or the person using the program.

Similarly, we will represent the suspect cards by s1 through s6, the location cards by l1 through l9 (i.e., a lowercase L, followed by a number from 1 to 9), and the weapon cards by w1 through w6.

To express that a player may be p1, p2, or p3 we can write in Prolog

```
player(P) :- (P=p1); (P=p2); (P=p3).
```

An alternative and terser expression, using the list features of Prolog, may be

```
player(P) :- member(P,[p1,p2,p3]).
```

provided that you include the classical membership function

```
member(X,[X|_]).
member(X,[_|Y]):- member(X,Y).
```

That is, X is a member of the indicated set if X equals the first element or if X is a member of the rest of the set.

Using the same mechanism, we will express that C is a card if C is of type suspect or of type location or of type weapon by writing

```
card(C) :- type(C,suspect).
```

and C is of type suspect if C is a

(continued)

member of the set [s1, s2, s3, s4, s5, s6], as expressed by

```
type(C,suspect):-
  member(C,[s1,s2,s3,s4,s5,s6]).
```

These rules for suspect cards and similar ones for location and weapon cards are given at the beginning of listing 1.

Two rules of the game constrain the card partition: the number of cards received by each player and the number of cards hidden in the box. In our simple system with three players and 21 cards, each player receives six cards, and the solution box contains only one card of each type.

GAME-DEPENDENT KNOWLEDGE

We must represent the information that emerges during the game. This includes, to start with, the cards that p1 (the person using the system) has received (such as s3, w2, w5, and so on). This knowledge is maintained by the system as the facts

```
has(p1,s3).
has(p1,w2).
has(p1,w5).
```

and so on. Note that Watson does not know, at first, what cards are held by players p2 and p3. During the game, however, new facts about these players owning a specific card (or not owning a specific card) may emerge and be inserted into the knowledge base.

First, we will get new facts when, following a question, a player (pi) shows a card (cj) to the player using the system, who will add the fact

```
has(pi,cj).
```

to the Watson knowledge base. If a player cannot show any of the three cards requested by the program, player p1 must insert three facts of the type

```
has_not(pi,cj).
```

into the knowledge base.

When a player shows a card upon the request of a player other than p1, we know that this player must have at least one of the three requested cards. Therefore, p1 will insert into the knowledge base a fact of the type

```
has_at_least_one_of_three
  (pi,cj,ck,cl).
```

Finally, when a player requests three cards, we can normally assume that the player does not have any of the requested cards. Otherwise, the request would not provide any new information. This assumption has its drawbacks: If a player requests, accidentally or by guile, to see three cards he or she holds, the program will fail to produce the solution! Nevertheless, in general we will have p1 add to the knowledge base a fact of the type

```
has_not_all_three(pi,cj,ck,cl).
```

STRATEGY

As we have pointed out, the knowledge base will also contain the rules. The rules represent the strategic knowledge that the program needs to make inferences as an expert player would. Strategies are in general hard to come by, but in this case, we think

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Listing 1: *The source code for the simple version of Watson developed in this article.*

```
player(P):-     member(P, [p1,p2,p3]).

type(C,suspect):- member(C, [s1,s2,s3,s4,s5,s6]).
type(C,location):- member(C, [l1,l2,l3,l4,l5,l6,l7,l8,l9]).
type(C,weapon):- member(C, [w1,w2,w3,w4,w5,w6]).
card(C):- type(C,suspect).
card(C):- type(C,location).
card(C):- type(C,weapon).

may_be_in_the_box(C):- card(C),
                       not (owns(p1,C)),
                       not (owns(p2,C)),
                       not (owns(p3,C)),
                       not (( type(C,T),
                              type(C1,T),
                              not (C=C1),
                              is_in_the_box(C1))).

is_in_the_box(C):-  owns_not(p1,C),
                    owns_not(p2,C),
                    owns_not(p3,C).

owns_not(P,C):- has_not(P,C).
owns_not(p1,C):- not (has(p1,C)).
owns_not(P,C):- (has_not_both(P,C,C1);
                 has_not_both(P,C1,C) ),
                 has(P,C1),
                 asserta( has_not(P,C) ).

owns(P,C):- has(P,C).
owns(P,C):- (has_at_least_one(P,C,C1);
             has_at_least_one(P,C1,C) ),
             has_not(P,C1),
             asserta( has(P,C) ).

has_at_least_one(P,C1,C2):-
          (has_at_least_one_of_three(P,C,C1,C2);
           has_at_least_one_of_three(P,C1,C,C2);
           has_at_least_one_of_three(P,C1,C2,C)),
           has_not(P,C).

ask(C):- may_be_in_the_box(C), !.

request(C1,C2,C3):- type(C1,suspect), ask(C1),
                    type(C2,location),ask(C2),
                    type(C3,weapon),  ask(C3).

member(X,[X|_]).
member(X,[_|Y]):- member(X,Y).
```

The order of the rules in a Prolog program is vital to its semantics.

that a few strategies are sufficient to beat most human players. However, we don't claim completeness and realize that you could elaborate and implement other strategic tricks.

Player p1 is confronted with two questions. The first is, "Do I have enough information to formulate an accusation?" In other words, "Can I deduce, using the current facts, which three cards are hidden in the box? If the answer to this question is no, which request will bring me information to formulate an accusation before the other players?" These two questions are related to the following basic ones:

1. When is it proved that a specific card is in the box?
2. When is it proved that a player does not own a specific card?
3. When is it proved that a player does not own two specific cards?
4. When is it proved that a player owns a specific card?
5. When is it proved that a player owns at least one of two specific cards?
6. Finally, which cards should the program tell player 1 to ask for?

We will present the rules designed to answer these questions, first in plain English and then in Prolog.

"When is it proved that a specific card C is in the box?" The answer is very straightforward: If it can be shown that none of the players owns this card, the card must be in the box. That is, if it can be shown that p1 does not own card C, p2 does not own card C, and p3 does not own card C, then C must be in the box.

In Prolog, we say

```
is_in_the_box(C) :- owns_not(p1,C),
                    owns_not(p2,C),
                    owns_not(p3,C).
```

Here we have introduced the predicate owns_not, which brings us to the second question: "When is it proved that a player does not own a specific card?" If the fact has_not(pi,cj) is already present in the knowledge base, the proof is trivial:

```
owns_not(P,C) :- has_not(P,C).
```

We introduced the predicate owns_not (which looks so similar to has_not) instead of just using has_not in the rule is_in_the_box to prevent Prolog from entering endless looping in the following clauses. Then owns and has have the same meaning, but we always prove "ownership" by using "having" arguments and never the other way round.

Regarding player p1, Watson can easily prove that he or she does not own a specific card by looking at the cards p1 *does* hold. If there is no has(p1,cj) fact in the knowledge base, it is proved that p1 does not own cj. In Prolog, this would be

```
owns_not(p1,C) :- not (has(p1,C)).
```

Let's remember here the difference between

```
has_not(pi,cj).
```

which means that it is proved, as a fact or by deduction from facts, that player pi does not have the card cj, and

```
not (has(pi,cj)).
```

which means that Prolog cannot *prove*, using current facts, that player pi has the card cj. When all cards of a player pi are known (and only then), we have

```
owns_not(pi,C) :- not (has(pi,C)).
```

as we did for p1 above. The condition "all cards of pi are known" could become true for any player during the game, but for the sake of simplicity we introduce the rule only for p1, because for this player the condition is true from the beginning of the play.

How can we answer the second question, "When is it proved that a player does not own a specific card?" for the players other than p1 and using the facts emerging during the game? If we have shown that a player does not own both of two specific cards and we have shown that he or she does own one of them, we have proved that the player cannot own the other one. In Prolog, this would be

```
owns_not(P,C) :-
     (has_not_both(P,C,C1) ;
      has_not_both(P,C1,C) ),
      has(P,C1).
```

Note the similarity between the fact has_not_both(P,C,C1) and the fact has_not_both(P,C1,C) in the subgoal of this rule. Here we are merely telling Prolog that the given facts are equivalent.

We have now introduced three rules containing owns_not. How does Prolog know that it must not use the second rule, owns_not(p1,C) :- not(has(p1,C), for players p2 and p3? This is accomplished by the unification mechanism of Prolog: owns_not(p2,C), for example, just doesn't match the rule for owns_not(p1,C), so Prolog will not try it.

On the other hand, how does Prolog know that it should use the first owns_not rule first, and only when this rule fails should it go on to the second and third owns_not rules? Here we see that the order of the rules in a Prolog program is vital to its semantics. In the logical formulation of a given problem the order of the clauses doesn't matter; in a Prolog program it most certainly does! Prolog always starts from the top trying to satisfy goals and continues downward as they fail.

In the third owns_not rule we introduced the has_not_both predicate. This predicate relates to the third question, "When is it proved that a player does not own two specific cards?" The answer: When a player does not own all of three specific cards and it is known that he or she does own one of them, the player cannot hold both of the other two. Thus, in Prolog we can say

```
has_not_both(P,C1,C2) :-
     ( has_not_all_three(P,C,C1,C2);
       has_not_all_three(P,C1,C,C2);
       has_not_all_three(P,C1,C2,C) ),
       has(P,C).
```

We will not introduce a rule for has_not_all_three only because

(continued)

Clearly, the program should have player 1 request cards that it believes, given its current knowledge, may be in the box.

has__not__all__three(P,C,C1,C2) is a fact that is inserted into the knowledge base during the game, as we have pointed out before, when a player shows no cards in response to a question.

This brings us to the fourth question, "When is it proved that a player owns a specific card?" When the card has been shown or when we know that a player owns at least one of two specific cards and we know also that he or she does not own one of them, then clearly the player must hold the other one. In Prolog we can say

```
owns(P,C) :- has(P,C).
owns(P,C) :-
    (has__at__least__one(P,C,C1);
    has__at__least__one(P,C1,C)),
    has__not(P,C1).
```

Now we will define a rule for the predicate has__at__least__one, introduced above. We must answer the fifth question, "When is it proved that a player owns at least one of two specific cards?" If we can show that a player has at least one of three specific cards and at the same time that he or she cannot own one of them specifically, then he or she must own at least one of the two other cards. In Prolog, that would be

```
has__at__least__one(P,C1,C2) :-
    (has__at__least__one__of__three
      (P,C,C1,C2);
    has__at__least__one__of__three
      (P,C1,C,C2);
    has__at__least__one__of__three
      (P,C1,C2,C) ),
    has__not(P,C).
```

Again, we will not define a rule for has__at__least__one__of__three because that is a fact, inserted into the knowledge base during the game.

We will now focus on the actions of the system as it advises player p1 during his or her turn. Clearly, the program should have p1 request cards that it believes, given its current knowledge, may be in the box. A card may be in the box when the program hasn't enough information to tie it to one of the players and when the program knows of no other card of the same type that is in the box. In Prolog, we can express that as

```
may__be__in__the__box(C) :-
    card(C),
    not (owns(p1,C)),
    not (owns(p2,C)),
    not (owns(p3,C)),
    not (( type(C,T),
           type(C1,T),
           not (C=C1),
           is__in__the__box(C1))).
```

Note that Prolog unifies the type T in type(C,T),type(C1,T).

Now we can answer the final question, "Which card should the program tell player p1 to ask for?" He or she should ask for a card that may be in the box, as shown in the code by

```
ask(C) :- may__be__in__the__box(C).
```

Here, it might be best to use the fact that the program probably has the most information about player p2 (the next player in the rotation of the game), but we have not added this, for the sake of simplicity.

The program must request to see three cards, each of a different type. So we have, in Prolog

```
request(C1,C2,C3) :-
    type(C1,suspect), ask(C1),
    type(C2,location),ask(C2),
    type(C3,weapon), ask(C3).
```

Prolog Rules

We have mentioned before that the order of the rules in a Prolog program matters. This means that you must consider how Prolog solves a problem. A more serious difficulty arises when the program is running too slowly, as in many cases it will do when using a Prolog interpreter. Then you are faced with the purely technical although important problem of speeding things up. One way is to commit Prolog to its previous conclusions. We will give two examples in the program we have written up to now.

In the owns rule, we establish the fact that a player owns a certain card. Once Prolog has done this, it should never have to bother to establish this fact again. To accomplish this we extend the owns rule by the predicate

```
asserta( has(P,C) ).
```

which will effectively add the fact has(P,C) to the knowledge base. Having ordered the owns rule the right way, Prolog will always first determine whether it has an appropriate previously asserted fact in its knowledge base before trying the other rule. The same remarks apply to the owns__not rule, which will be extended with

```
asserta( has__not(P,C) ).
```

Therefore we present new versions for these rules:

```
owns(P,C) :-
    (has__at__least__one(P,C,C1);
    has__at__least__one(P,C1,C),
    has__not(P,C1),
    asserta( has(P,C) ).

owns__not(P,C) :-
    (has__not__both(P,C,C1) ;
     has__not__both(P,C1,C) ),
     has(P,C1),
     asserta( has__not(P,C) ).
```

To commit Prolog to choices it has made within a rule we must use Prolog's cut mechanism, implemented via a trailing exclamation point. We have an example in the request rule. Once Prolog has found a suitable card to ask of the suspect type, it should never go back on this choice when it is trying to find suitable cards to ask of the location and weapon types. This means that we must force Prolog to skip the ask(C) goal when backtracking. So we have as a new version of the ask rule:

```
ask(C) :- may__be__in__the__box(C), !.
```

Using the System

Before using the simple version of Watson described here (and shown in listing 1), you must invoke the Prolog interpreter and then load the program. After this, you have two possible actions: adding facts to the knowledge base and getting advice from the system.

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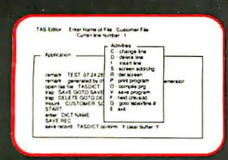
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Two elegant aspects of Prolog are well illustrated by the Watson example, backtracking and the use of variables.

Before starting the game, you must insert facts about your cards (p1's cards) into the knowledge base, using the asserta predicate

```
asserta( has(p1,s3) ).
asserta( has(p1,w2) ).
```

and so on. During the game, you may insert new facts into the knowledge base. When a player cannot respond to a given request, you may add three has_not facts, as in

```
asserta( has_not(p2,s3) ).
asserta( has_not(p2,l4) ).
asserta( has_not(p2,w1) ).
```

When a player responds to a request from you, you can add one has fact, such as

```
asserta( has (p2,s4) ).
```

When a player responds to a request of another player, you may insert a has_at_least_one_of_three fact, as in

```
asserta( has_at_least_one_of_three
         (p3,s3,l7,w4) ).
```

When a player (e.g., p2) other than yourself (p1) makes a request, you can add one has_not_all_three fact about that player to the knowledge base, as in

```
asserta( has_not_all_three
         (p2,s3,l2,w5) ).
```

To get advice from the system when it is your (p1's) turn, you should enter the goal

```
request(C1,C2,C3).
```

The program will instantiate C1, C2, and C3 to, respectively, a suspect, a location, and a weapon that may be in the box. Early in the game, there may be many possible combinations of three cards in the box, and Prolog will present you with all of them, if you desire, usually by asking if you want to see more. You present player p2 with one of these requests and, depending on the response from p2 (and possibly p3), you may then enter new has or has_not facts, as above. Eventually, the program will suggest three cards for you to request, none of which is held by any player, and these are the cards that must be in the box.

Finally, you may ask questions about the state of the game. To see, for instance, what facts the system has derived, you ask Prolog to satisfy the goal

```
listing(has).
```

and the program will present a list of which player is known to have which card.

THE PROS AND CONS OF PROLOG

Two particularly elegant aspects of Prolog are well illustrated by the Watson example, namely, backtracking and the use of variables. The backtracking frees the programmer from coding the search through the tree of hypotheses and from the related administration. The use of variables allows a terse formulation of the program constraints.

Three less attractive aspects of Prolog have also been encountered in the Watson exercise. The first is the danger of loops, which forced us to introduce the unnatural distinction between has and owns. We quote from the book by Clocksin and Mellish mentioned earlier: "Don't assume that, just because you have provided all the relevant facts and rules, Prolog will always find them. You must bear in mind when you write Prolog programs how Prolog searches through the database and what variables will be instantiated when one of your rules is used."

The second aspect is related to the fact that Prolog only accepts Horn clauses (no disjunctions in the left part). This restriction, which permits the Prolog system to pursue goals efficiently, is sometimes frustrating and leads to the necessity of describing the problem in a more complex way. For instance, in Watson the clause has_at_least_one_of_three is required only because we are not permitted to write it as a fact with disjunctions, as in

```
has(pi,cj); has(pi,cj'); has(pi,cj").
```

The third less attractive aspect is related to quantitative aspects of the problem. In the approach described in this article, Prolog investigates deeply the known facts and their consequences, avoiding useless questions. It would be more complicated to make Prolog compare various questions, deciding which one is the best, that is, providing a maximum of information to p1 and a minimum of information to the other players. The concept of entropy can be useful in this respect.

The less attractive aspects of using Prolog could be at least partially overcome by incorporating a loop-detecting and escape feature; a preprocessing step, transforming some non-Horn clauses into Prolog clauses; and a tight link to procedural programming languages. By a tight link we mean the ability to call Prolog from the procedural language and vice versa and to have an efficient transfer of data (the current instantiation of the variables) between both program parts. There is a trend to incorporate these functions into Prolog environments. In our opinion this is an important aspect of the usefulness of Prolog.

ACKNOWLEDGMENT
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Editor's note: Watson is available on disk, in print, and on BIX for the IBM PC and compatibles using DOS 2.1. See the insert card following page 352 for details. This program is also available on BYTEnet. See page 4. Listing 1 is available as WATSON.PRO, and you will need a Prolog interpreter to use it. A more complete version of Watson, with menu-driven user interface, is also available. You will need micro-PROLOG 1.21 to run this version of Watson, or you can adapt it to work with another Prolog interpreter. ■

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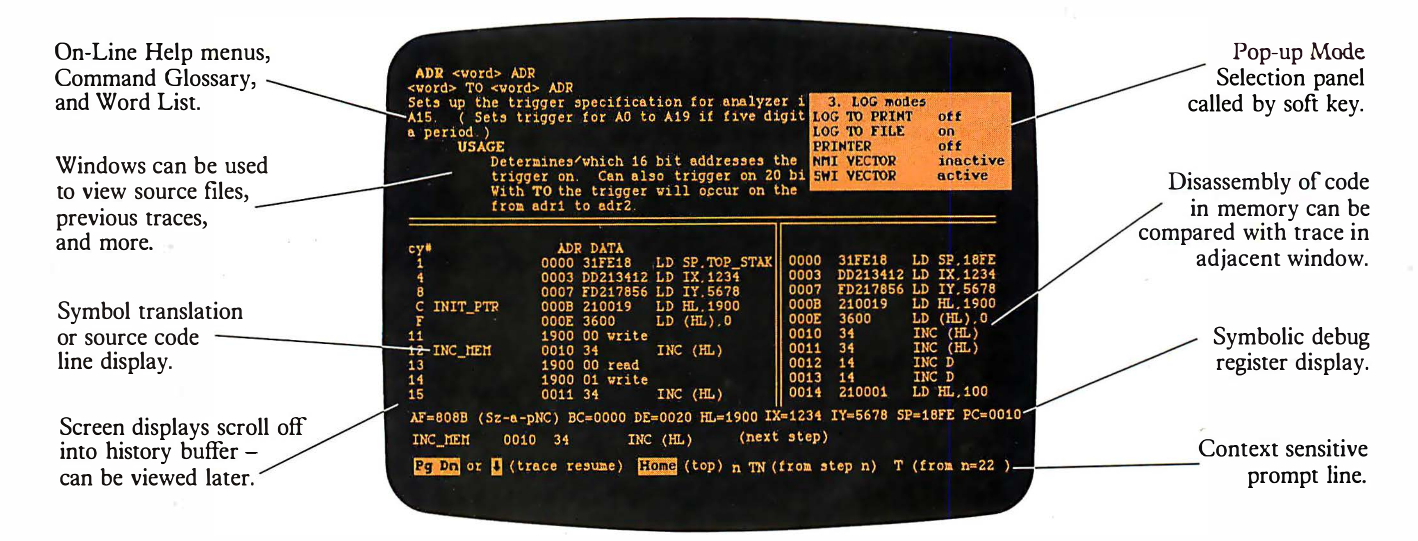




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RULE-BASED PROGRAMMING

BY LEONARD MOSKOWITZ

OPS5 *lets you add knowledge to a program without worrying about where to put it*

THE WAY IN WHICH a computer program represents knowledge affects how it can apply and manipulate that knowledge. A good representation makes important features explicit and hides or ignores unimportant ones. Any particular representation may serve well for one task but be less appropriate for another—even closely related—task. For example, Roman numerals are appropriate for representing fixed quantities but not for performing mathematical calculations.

In the field of computer science in general, and artificial intelligence (AI) in particular, the advantages of good knowledge representation are well appreciated. A computer program that displays intelligence must be able to manipulate knowledge in a straightforward manner. The more appropriate the knowledge representation is to the task at hand, the easier the task is to accomplish.

Starting with a collection of basic mathematical theorems, Doug Lenat's discovery program, AM, was able to discover, or rediscover, many mathematical concepts. Its power was traced to its form of knowledge representation. AM used structured LISP modules that represented knowledge in the Math domain at the proper level of abstraction. Syntactic mutations to these LISP modules resulted in corresponding changes in the Math domain. Since the modules represented knowledge at comparable levels of abstraction, a change to a LISP function had a good chance of causing a reasonable change in the Math domain, too.

While traditional procedural programs embed and intertwine knowledge and program control, expert systems—AM, for example—explicitly separate knowledge and program control. This approach is called knowledge-based programming and may be the key contribution of expert systems to computer science.

Many well-known expert systems are built using production systems. First formulated by Allen Newell and Herbert Simon at Carnegie-Mellon University as a model of human cognitive architecture, production systems represent knowledge as a set of condition-action rules, or productions. Production systems stress the use of independent knowledge modules. Ideally, you should be able to add and delete knowledge (productions) without worrying about how the productions interact.

OPS5 is the production-system language that has found widespread acceptance in the AI research and development communities. The earliest version of OPS (which its authors, with tongue in cheek, say stands for "Official, at least locally, Production System") was written at CMU in the mid 1970s.

PRIMARY CONSTRUCTS

The name production systems (which are also called rule-based systems) comes from the primary programming construct that they use—the production. An OPS5 production, or rule (the terms are interchangeable), has four parts: a title, a left-hand side (LHS), an arrow symbol (—>), and a right-hand side (RHS). The LHS has a number of patterns called condition

(continued)

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elements. The RHS has a number of actions. If the LHS patterns are matched, or satisfied, the RHS actions are executed. You can think of a production as an IF. . .THEN rule, with the LHS corresponding to the IF part and the RHS to the THEN part.

Listing 1 contains an example of a simple OPS5 rule that translates into English as follows (note that the attributes are those preceded by the symbol ^):

• This production's title is I'm-cold.
IF
• working memory has an element that has as its contents the class name temperature and the attribute value that has the value cold (call that element local-temperature), and
• there is another element in working memory that has as its contents the class name window and the attribute state that has the value open (call this element open-window),
THEN
• modify the element called local-temperature by modifying the value of the attribute value to getting-warmer?, and
• modify the element called open-window by changing the value of its attribute state to closed, and
• tell the world that you were cold and closed the window.

```
(literalize house
    address
    size-of-property
    number-of-rooms
    type-of-heating
    taxes-per-year
    asking-price)
```

Figure 1a: A *literalization.*

OPS5 keeps information in two places: production memory, which holds all the productions, and working memory, which holds the data against which the LHSs are matched. The elements in working memory are time-tagged: The most recent addition has the highest time tag.

In traditional procedural languages like C, Pascal, or BASIC, program control can be transferred via conditionals, subroutine calls, function calls, and explicit directions. If none of these is present, the program executes sequentially. In OPS5, however, productions can be entered in any sequence. Regardless of where you place a production in the program, it will be executed when the conditions defined in its LHS are satisfied best by the data in working memory.

The control mechanism that determines execution order is called the match-resolve-act cycle. The match part identifies the conflict set, those productions that match the current state of working memory. Since the conflict set may include more than one production, the conflict resolver selects the one production that is satisfied best and arranges for that production to act, or fire—that is, to execute its RHS.

```
(house 1402_Main_Street 1/2-acre 7 oil/gas $1500 $120k)
```

Figure 1b: *An instance of the literalization.*

Listing 1: A *simple* OPS5 *production.*

```
(p I'm-cold
     {(temperature ^value cold) <local-temperature>}
     {(window ^state open) <open-window>}
-->
     (modify <local-temperature> ^value getting-warmer?)
     (modify <open-window> ^state closed)
     (write (crlf)
            |Brrr! I was cold so I closed the window.|))
```

The ability to add productions to a program without worrying about where to put them is one of the nicest features of OPS5. Production systems try to isolate the knowledge required to do a task from the way that knowledge is applied to teach a program what to know rather than what to do. They don't always succeed in separating the knowledge from the control, but OPS5 does a much better job of it than the traditional procedural languages.

A Deeper Look

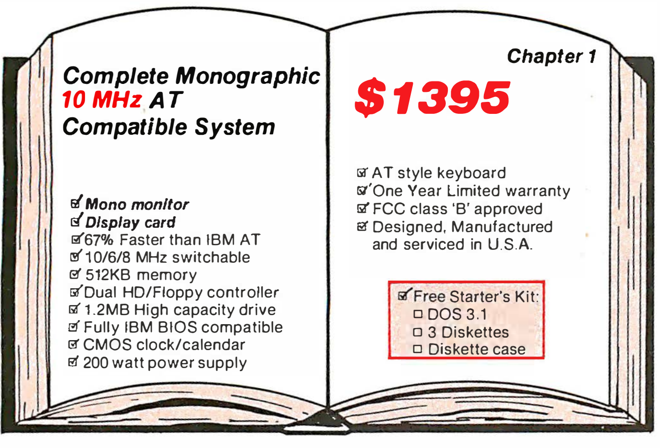
Literalization. In OPS5, the only actual structures are the working memory elements, which typically take the form of a class name followed by the values of the class's various attributes. A literalize statement is used to declare the class. Figure 1a shows a literalization from a hypothetical expert system for real estate agents. It contains a class house with six attributes: address, size-of-property, number-of-rooms, type-of-heating, taxes-per-year, and asking-price. While the production system is executing, working memory may contain many instances of this class that vary only in the values bound to the attributes. Figure 1b shows one instance of this literalization.

OPS5 also requires that you declare references to external functions or subroutines. This declaration uses the name of the function or subroutine as an argument to the keyword external.

The Left-hand Side. The LHS of a production consists of patterns called condition elements, each of which consists of an opening parenthesis, some number of terms, and a closing parenthesis. The terms are typically class names followed by attribute-value pairs (as defined in the literalize statements). An attribute is usually denoted by a preceding ^ symbol. For example, in listing 1, the class name is temperature, the attribute is ^value,

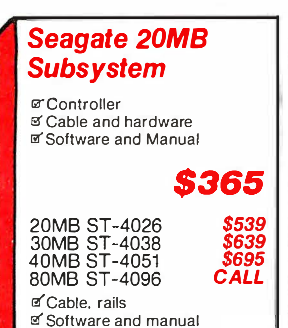
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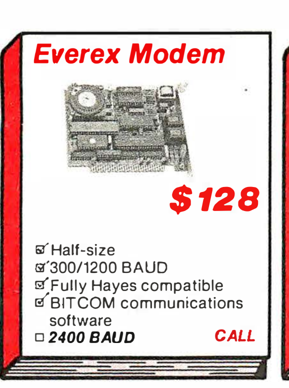
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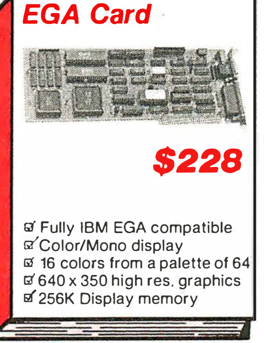




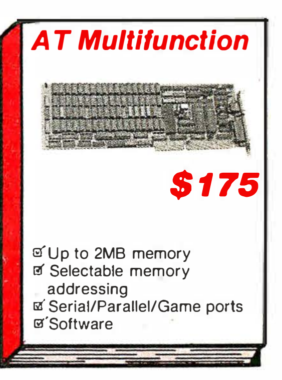
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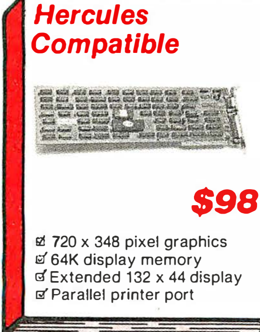






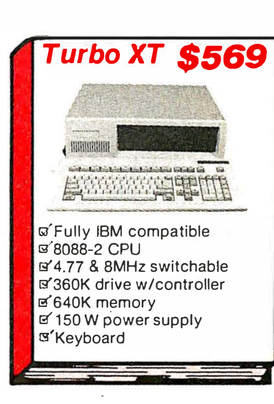












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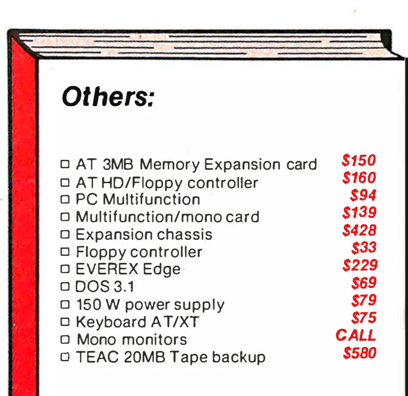
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and the value of the attribute is cold. Values can be specified as constants—cold is a constant—or by using OPS5's LHS pattern operators, which are listed in table 1.

Table 1: *The LHS pattern operators.*

Name	Description
Variable	The first time a variable is used in a production, it is bound to the working memory value it matches. Every subsequent time it is used in the same production, it matches the value previously bound.
Disjunction	Any of the values enclosed in pointed double brackets (< < . . . > >) is an acceptable match.
Conjunction	The working memory value must match all the items in the curly brackets ({ . . . }).
=	Matches a value exactly.
< >	The working memory value may be anything but the argument of this operator.
< = >	The working memory value must be the same type—numeric or symbolic—as the argument to this operator.
<,<=,>=,>	The working memory value must be, respectively, less than, less than or equal to, greater than or equal to, or greater than the argument to this operator.
//	The symbol used as an argument will be matched literally and not evaluated.

Table 2: *The RHS actions.*

Name	Description
make	Creates a new working memory element.
remove	Removes an element from working memory.
modify	Changes one or more values in a working memory element.
openfile	Opens a file for either reading or writing and associates a name with it.
closefile	Closes the file associated with the argument.
default	Sets the default file or stream used for input, output, and trace information.
write	Writes output to a designated stream or file.
call	Invokes user-written subroutines.
halt	Stops the interpreter from firing further productions once the current one has completed.
bind	Binds a variable to a value.
cbind	Binds a variable to the last working memory element created by this production.
build	Adds a new production to working memory.

You can match the contents of working memory in various ways: You can make an exact match by using a constant value or a bound variable (a variable with an assigned value); you can match any value by using an unbound variable (a variable that doesn't yet have an assigned value); and you can place limits on the values you will match by using any of the seven predicates (the logical operators <, < =, > =, >, < >, =, and < = >) combined with the disjunction (< < . . . > >) and conjunction ({ . . . }) operators. You can also match the absence of an element.

The Right-hand Side. Once the LHS is satisfied and the production is selected to fire, the production's RHS executes. The RHS consists of a sequence of actions (see table 2). These actions can add, delete, and modify elements in working memory, open and close files, perform input and output, assign values to variables, call user-defined procedures, and halt the program. In some implementations, an action can add productions to the program, thus allowing self-modifying, or learning, programs.

Each action consists of an opening parenthesis, the action's name, its arguments, and a closing parenthesis. The arguments can be element designators that provide a way for an RHS action to refer to the working memory element that a particular LHS condition element matches. (In listing 1, local-temperature and open-window are element designators.) An action's arguments can also be patterns similar to LHS condition elements. These patterns may contain variables that must be resolved into values and function references that must return a value before the RHS action executes. When these are resolved, the evaluated pattern is called the result element.

Table 3 lists the functions that OPS5 provides. They can extract pieces of a condition element for an RHS action to use, do arithmetic computation, and read input from a variety of sources. Functions also return their results into the result element.

Resolving Conflicts

A conflict resolver should be simple, efficient, and straightforward and should fulfill certain basic needs. First, a particular production/working-memory-elements match, an instantiation, shouldn't fire over and over again. This would be equivalent to getting stuck in a very tight loop. You can

Example	Explanation
<x>	
<< yes no maybe >>	The matched value must be either yes, no, or maybe.
{>10 <20}	The matched value must be greater than 10 and less than 20.
=3	The matched value must be 3. (This is the same as just using 3 without the =.)
<>3	The matched value may be anything but a 3.
<=> 123	The matched value must be a number.
<=> ABC	The matched value must be symbolic.
>= 42	The matched value must be greater than or equal to 42.
<0	The matched value must be a negative number.
// <x>	The matched value must be <x> and not the value bound to the variable <x>.

<table>
<tr><th>Example</th><th>Explanation</th></tr>
<tr><td>(make house ^price $120k)</td><td>Adds this element to working memory.</td></tr>
<tr><td>(remove 1 <ranch>)</td><td>Removes the working memory elements that have been bound to the element designators 1 and <ranch>.</td></tr>
<tr><td>(modify <ranch> ^type modern)</td><td>Modifies the type attribute of the working element that is bound to <ranch>.</td></tr>
<tr><td>(openfile testfile |test.asm| out)</td><td>Opens a file named test.asm for writing and assigns the name testfile to it.</td></tr>
<tr><td>(closefile testfile)</td><td>Closes the file associated with testfile.</td></tr>
<tr><td>(default nil trace)</td><td>Uses the user's terminal to display trace information.</td></tr>
<tr><td>(write testfile (crlf) |Hi!|)</td><td>Writes a new line with the string Hi! to the file associated with testfile.</td></tr>
<tr><td>(call calculate)</td><td>Invokes the user-written subroutine entitled calculate.</td></tr>
<tr><td>(halt)</td><td></td></tr>
<tr><td>(bind <x> 3)</td><td>Binds the variable <x> to the number 3.</td></tr>
<tr><td>(cbind <last>)</td><td>Binds the variable <last> to the last element added to working memory.</td></tr>
<tr><td>(build a-new-one (3) (10) --> (halt))</td><td>Builds a new production called a-new-one that matches a 3 and a 10 and halts.</td></tr>
</table>

either exclude an instantiation from ever firing more than once—OPS5's method—or ensure that it can't fire twice in a row. Second, execution should stick to one task at a time and not switch tasks needlessly. In effect there should be an attention mechanism. OPS5 gives preference to those instantiations that include the most recent additions to working memory. In this way, attention stays focused, and simple sequential execution can be implemented if necessary. Third, the more specific productions should be preferred over the less specific ones, ensuring that the rule that best fits a particular situation will fire. Finally, when none of these strategies applies, you need a rule to fall back on. OPS5 selects a production arbitrarily from the conflict set.

OPS5 has two conflict-resolution strategies that fulfill these needs but differ slightly in detail: LEX and MEA. LEX is simpler than MEA, but MEA provides more explicit execution control than LEX. The choice of which to use depends on the application.

The LEX strategy first discards from the conflict set all instantiations that have previously fired. If none remains, control returns to the top level. If more than one remain, LEX selects the most recent instantiations. If more than one are selected, LEX chooses the most specific. If more than one still remain, it arbitrarily picks one.

The MEA strategy has one more step. It first discards from the conflict set all instantiations that have previously fired. If none remains, control returns to the top level. If more than one remain, MEA compares the *recency* of the working memory elements that satisfy the *first* condition element of the instantiations and selects the most recent instantiations. It then chooses the most recent instantiations considering the entire LHSs (not just the first condition element). If more than one remain, MEA selects the most specific. If more than one still remain, it arbitrarily picks one.

Pattern Matching

The pattern matcher is the heart of OPS5. Estimates of the execution time spent in the match phase are as high as 90 percent of the total, so optimizing the match algorithm pays high dividends. OPS5 uses the Rete match algorithm, written by Charles Forgy, in which each pattern in a production maintains a list of the elements that satisfy it. When you add an element to working memory, you also add it to the lists of all the patterns that match it. When you remove an element from working memory, you remove it from those lists as well. The

(continued)

lists are retained between match-resolve-act cycles. Therefore, you never have to evaluate the entire contents of working memory.

To implement the Rete match algorithm, OPS5 uses a tree-structured sorting network for the productions. This Rete network is compiled for the LHS patterns and acts as a black box with changes to working memory as its input and changes to the conflict set as its output. The Rete network functions as a state memory that changes as you add or remove elements from working memory. This network is the key to OPS5's efficiency.

CONTROL ISSUES

When you first experiment with OPS5, you may tend to write programs with strictly sequential execution that proceed from firing to firing in an explicitly defined order. It takes a while to realize that a large part of OPS5's power is that the language will handle the details of execution if you let it.

Listing 2 contains a sort program that uses only one production to print a sorted list of all the numbers in working memory. The program assumes that working memory holds some numbers, or elements, with the class name number and a value attribute with the value yes or no to indicate whether or not this number has been printed. Initially all the printed-yet? attributes are set to no. The program translates into English as follows:

- The title of this production is sort.

IF

- there is a number that has not yet been printed (call the number x and its working memory element smallest), and
- there isn't another unprinted number that is smaller than x,

THEN

- write out x on a new line, and
- mark the working element called smallest as printed.

The production fires continuously, printing numbers from the smallest to the largest. When it prints a number, it sets that number's printed-yet? attribute to yes so the production never matches it again. Execution halts when no more numbers have their printed-yet? attributes still set to no.

On each cycle OPS5's pattern matcher tries to satisfy the LHS. The order in which the numbers are checked against each other doesn't really matter, so you needn't write detailed code to control it. In OPS5, the pattern matcher and the conflict resolver handle this chore. Listing 2 remains compact and describes only what a sort is, not exactly how to do it. (For a description of a small but

Table 3: *The RHS functions.*

Name	Description
substr	Extracts part of a working memory element and returns it to the result element.
genatom	Creates and returns a new symbolic atom.
compute	Returns the evaluation of an arithmetic expression.
litval	Returns the number assigned by the literalize function.
accept	Returns the value received from the input stream or file.
acceptline	Returns exactly one line of input from the input stream or file.

A SMALL RULE-BASED SYSTEM

AUTO.OPS is a small OPS5 production system that diagnoses some simple electrical problems in automobiles. [*Editor's note:* AUTO.OPS *is available on disk, in print, and on* BIX; *see the insert card following page* 352 *for details. It is also available on* BYTE*net; see page* 4.] It's 36 productions long; knows about the battery, headlights, radio/cassette player, and fusebox; asks you for symptoms of the failure (dead radio, one headlight out, etc.); and tries to gather evidence to make a diagnosis. Listing A shows a sample run.

The program is broken up into four parts. The first is the literalization section, where the working memory elements are described and declared. These are the current phase of the program, the symptoms noted, and the answers to the yes/no questions the program asks. The second is the data-entry section, which has seven productions to print the symptom menu, accept the symptoms, place them in working memory, check for invalid and duplicate ones, and set up the diagnosis phase. The third part does the diagnosis and has 26 productions. It notes what symptoms you entered, infers certain things (like the battery is not dead because at least one thing is working), and asks you to run tests and report their results until it narrows the problem down. The fourth part, only three productions long, cleans up the working memory and restarts the program.

The only explicit control used in AUTO.OPS is the phase working memory element. It serves to partition the productions into three groups, simplifying conflict resolution and debugging. At first its current-phase attribute is set to data-entry. When you finish entering symptoms, current-phase is set to diagnose. When no more specific rules can fire in the diagnose phase, the production entitled catch-all-production fires, changing current-phase to clean-up.

Typical of expert systems, you can extend this production system incrementally with relative ease. If you wanted to consider symptoms associated with an alternator, you could add productions to accommodate them. If the existing production system is well-structured, few of the preexisting productions should need to be modified. A good learning exercise would be to extend this system. If you do, please let me know how it turns out.

Example	Explanation
(substr <wme> 3 3)	Extracts and returns the third value from the working memory element associated with <wme>.
(genatom)	Returns a new symbolic atom.
(compute <number> + 2)	Returns the sum of 2 and the value bound to the variable <number>.
(litval price)	Returns the value assigned to price.
(accept input-stream)	Returns the value received from the input stream called input-stream.
(acceptline input-stream)	Returns one line of input from the input stream called input-stream.

Listing A: A *sample run of* AUTO.OPS (*user input shown in uppercase letters*).

```
What's wrong with the old heap now?

                       dead-radio
                       dead-cassette
                       no-headlights
                       one-headlight-out

Choose your symptoms from the list and type "end" to finish
or "quit" to exit.
                       Symptom: DEAD-RADIO
                       Symptom: END

Is the cassette dead too? (yes/no): YES

Since both the radio and the cassette are dead, check the
fuse for the radio.

Is it blown? (yes/no): NO

Hmm. Both the radio and cassette are dead, the radio fuse
is ok, and we're still not getting power.  Turn on your
headlights.

Are they both on? (yes/no): NO

Is one headlight on? (yes/no): YES

Very curious.  It appears that the battery is ok, but still
no radio.  It could be a broken wire somewhere.  Get out a
voltmeter and a schematic and trace back from the radio.  If
there's voltage at the radio, then remove the radio for
repair.  Otherwise, I'm stumped. Sorry!

Replace the dead headlight with one of the same type.

Done.  Starting over.
```

more involved OPS5 system and access to its code, see the text box "A Small Rule-based System.")

The Top Level

There are two original versions of OPS5, one written in LISP and one in BLISS, with only minor variations between them. OPS5 is an interpreted language. As in BASIC, you can enter commands to the interpreter, or the top level. In the LISP version, when you enter OPS5, you are automatically at the top level. In the BLISS version, you must compile the productions and link in the OPS5 interpreter. You don't see the top level until you run the program.

The top level is a loop that accepts one command, executes it, and waits for another one. At the top level you can enter productions (either manually or by loading a prewritten file), examine and excise productions, examine and modify working memory, open and close files, invoke user-defined external procedures, step forward (and, in the LISP version, backward) through the execution of a production system, run a production system, select the conflict resolution strategy, select the amount of trace information the production system reports as it executes, show which productions are in the current conflict set, set breakpoints, and exit from OPS5. When a production system finishes executing, control returns to the top level.

Interfaces

OPS5 is a language for building and applying a knowledge base, but it is not especially efficient for numerical computation, database operations, list processing, or any process that requires lots of file interaction. If you have an application that combines these needs, it would be nice to be able to program each section of it in the language best suited to its function. This would require that all of the languages and their environment or operating system support communications between programs in different languages. OPS5 has a variety of functions that simplify the task of interfacing with or embedding OPS5 programs.

OPS5 supports external user-defined RHS actions and functions. (Actions don't return a value; functions do.) The RHS action call lets you write your own actions. The language provides specific functions to ease the task of interfacing with external procedures by standardizing the transfer of information into and out of OPS5. These functions can pass parameters to an external procedure, allow that procedure to add to working memory, and access objects (e.g., files, streams)

(continued)

that OPS5 has opened for input or output. You can also write your own external functions. You simply declare their invocation names as external and use them as you would use any OPS5 function.

PARALLELISM

OPS5 would seem to lend itself well to an implementation on a parallel computer. Bruce Hillyer and David Shaw modeled OPS5 on a small version of the massively parallel Non-Von machine they are building at Columbia University. By apportioning OPS5's Rete match network among its small processing elements (SPEs), they predict improvements in execution speeds on the order of 100 times the speed of the fastest currently available OPS5 implementation, or roughly 900 production firings per second. The architecture they suggest is a parallel machine with 32 large processing elements (processors with the capability of a Motorola 68020), approximately 16,000 SPEs (8-bit processors with only 64 bytes of RAM each), and a few intelligent disk servers. Such a machine would cost approximately what a VAX-11/780 costs today.

Remember that the OPS5 language was written for sequential machines. You can expect that production systems written expressly for parallel architectures would execute much faster than OPS5.

SHORTCOMINGS

Personally, I think OPS5 is wonderful, but it does have its shortcomings. The price you pay for perspicuity of knowledge representation is speed. The BLISS version runs at between 5 and 12 firings per second on a single-user VAX-11/780. The LISP version runs a bit faster on the specialized LISP workstations. While you could improve speed if you recoded the logic in C or Pascal, you would lose the advantages of a knowledge-based system. You wouldn't be able to add knowledge incrementally, and maintenance would be a nightmare because you would have to contend with a program that mixes knowledge and control.

OPS5's Backus-Naur form (BNF) syntax is simple and easy to learn, taking up less than two pages. (BNF is a formal language used to express context-free grammars.) However, it lacks some important features. You can't do computations in an LHS condition element, so the possible range of a match is restricted. There is no disjunction across condition elements, so you must code X or Y or Z as separate productions. (Forgy suggested that an easy way around this syntactical barrier would be to write a preprocessor that takes a disjunctive form and generates appropriate conjunctive productions.)

OPS5 doesn't provide a means of segmenting independent groups of productions into separate rule bases within a single program. A 3000-production system takes much longer to execute as a whole than three 1000-production systems that maintain independent Rete networks and are activated only when appropriate.

Some programmers call the inability to do traditional procedural programming from within OPS5 a shortcoming. I call it a feature. As long as it provides the "hooks" to interface with other languages, the last thing we need is another procedural language. There is a modular elegance in working in the language best suited to a task. I think we need more special-purpose languages—like Prolog for logic programming, or perhaps a brand-new frame-based language—that integrate with traditional languages as well as OPS5 does. However, if this concerns you, OPS83, Forgy's latest version of OPS, has a Pascal-like syntax for doing procedural programming.

Listing 2: *A one-production sort program.*

```
(p sort
    {(number ^value <x> ^printed-yet? no) <smallest>}
    -(number ^value < <x> ^printed-yet? no)
-->
    (write (crlf) <x>)
    (modify <smallest> ^printed-yet? yes))
```

AVAILABILITY

OPS5 was originally written on a DECsystem-20. It has now been ported over to the Apple Macintosh (ExperTelligence), the IBM PC (Dynamic Master Systems), CP/M-80 (Dynamic Master Systems), the LISP machines (Symbolics, LMI, and Xerox, with user-interface enhancements from Verac Inc. and SAIC), the VAX (a BLISS version supported by DEC and a version in Franz LISP), and the Apollo workstations (from Cognitive Systems via Yale's T dialect of LISP and Computer*Thought).

SUMMARY

OPS5 is a powerful language that relies on some very simple ideas. Its strength is in representing knowledge in the surprisingly flexible form of IF. . .THEN rules. If such a thing as a standard tool for building knowledge-based systems exists, OPS5 is it. Its syntax is simple, and it has a simple interface to other languages. Until recently, it was available only to those with access to large computers. Thanks to the new microcomputer versions, it's now available to all of us. ■

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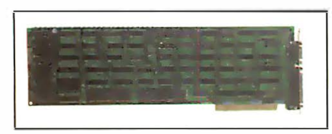
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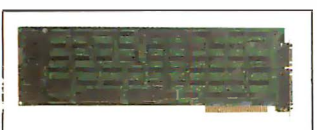
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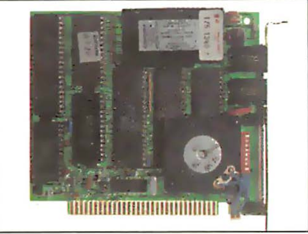
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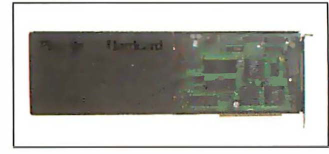
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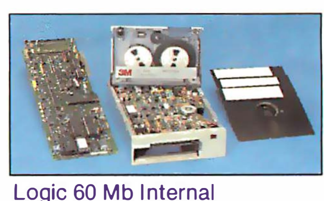
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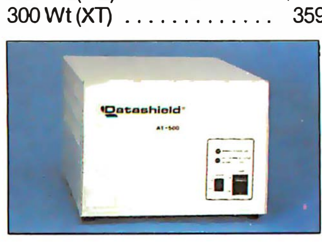
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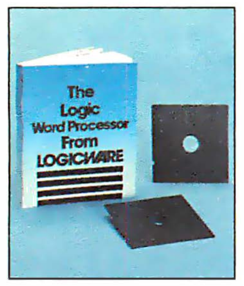


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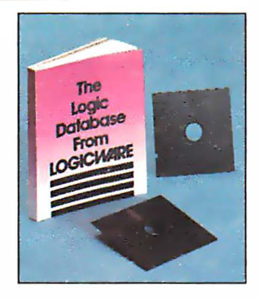
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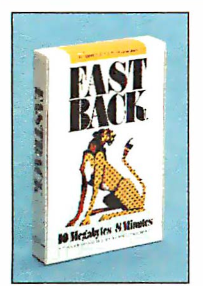
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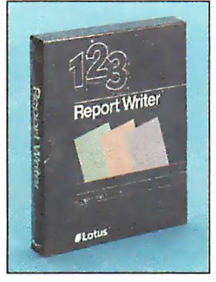
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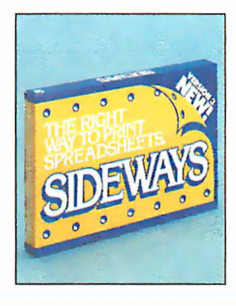
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BY ANGELOS T. KOLOKOURIS

One approach to teaching computers to learn is with a language, such as Marvin's, that grows

IN AN ATTEMPT to make computers more accessible to humans, many researchers in the artificial intelligence field have been exploring ways to enable computers to learn. The motivation for machine learning is to have computers extract concepts and relations from databases or through interactive sessions with a user and then use them in any knowledge-intensive activity. Developing knowledge bases for expert systems applications is one such activity. Studying computer-based learning techniques will also give us a better understanding of our own mental processes.

A common method by which a machine learns is by proceeding from specific instances to general rules that more economically capture the content of the given instances. This form of inductive generalization is characteristic of learning from examples and improves on the performance of a knowledge-processing system by condensing a large base of its knowledge into a considerably smaller one. This reduction in size results in a more efficient search of the knowledge base.

When you take a closer look at the programs that learn from examples, you can distinguish two types: those, called data-driven learners, that generalize by relying entirely on the data presented to them, and a group of more elaborate programs, called model-driven learners, that proceed by generating fairly general hypotheses that are subsequently tested against the given examples or against the user in a typical interactive session. In what follows I will contrast the model-driven learner with the data-driven learner and give an example of the former using a model-driven learner called Marvin. [*Editor's note: The Prolog source code for Marvin is available on disk, in print, and on* BIX; *see the insert card following page 352 for details. It is also available on* BYTE*net; see page 4.*]

WHAT IS LEARNING?

To give you an idea of just what's involved in modeling learning with computers, I should examine just what learning is. The best definition of learning that I am aware of—that of Herbert Simon of Carnegie-Mellon University (reference 1)—is that "learning denotes changes in the system that are adaptive in the sense that they enable the system to do the same task or tasks drawn from the same population more efficiently the next time." Taking a closer look at this definition, however, you may realize that it deals predominantly with skill acquisition or improvement, but not all learning is so concerned. Learning systems are those that are able to extract knowledge from raw data or through intersystem informative exchanges, including conversations with the user. Learning systems ought to have the ability not only to acquire knowledge in a cumulative form but also to absorb it.

MACHINE LEARNING STRATEGIES

The methodologies used in machine learning applications with some degree of success are rote learning, learning by being told, learning by analogy, and learning from examples. In rote learning the computer makes no special effort to learn. The elements of new knowledge are given to it, through programming or by accessing an external data file, and inferenc-

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ing is not required. Rote learning relies entirely on memorization, and it is debatable whether programs in this category display learning at all. This simplistic learning function is demonstrated by a checkers-playing program that learns the board positions it evaluates in its look-ahead search. In learning by being told general knowledge is modified into a form that the machine can recognize. The learner transforms the advice given into a set of statements that directly relate to what it already knows. This incorporation of new knowledge may facilitate further explanatory paths in the system's operation. In learning by analogy the knowledge given to the computer is not directly relevant, and the computer must hypothesize analogous cases to assist in solving the problem at hand.

In learning from examples the computer proceeds from individual cases to general principles, from particulars to universals. The problem of concept learning can be seen as the task of developing a classifying rule from several examples of proper membership in the investigated class. Learning from examples is the most successful method of machine learning today and has the longest history. Categorization was seen by Aristotle as the most fundamental step toward learning. In his attempt to provide a formal framework for the study of the way people acquire and process knowledge, he noticed that it is by inductive generalization that people get to know the set of objects that figure in the domain of their activity.

In their quest for knowledge people seek answers to basic questions like why and what. While why-questions are answered through the use of deductive logic, what-questions (i.e., those that relate to the task of taking stock of the foundations of descriptive language) are answered through inductive methods. Since Aristotle's day inductive techniques have been controversial, particularly regarding the degree of unsupervised function to which they are entitled.

KNOWLEDGE REPRESENTATION

A related issue is representation. The properties of the objects you want to account for must be described in a particular language that accommodates such descriptions. A problem arises when you want a learning system to operate in different environments. A way to get around it is by choosing a flexible enough language to which you can add domain knowledge that reflects the peculiarities of the chosen environment.

In the early years of research on learning systems, R. B. Banerji (reference 2) suggested that rather than choose a language that is confined by the structure of the objects it is used to describe, a better choice would be a language that can "grow." He proposed that such a language could be developed using the predicate calculus as a starting point. This type of language would enable a learning program to create descriptions by learning the domain knowledge. The upshot of this approach is that the language becomes richer as more knowledge is acquired. The learning system learns concepts that can be used in future learning.

DATA-DRIVEN LEARNERS

Here is a simple example of how a data-driven learning program functions. Assume that the data-driven learner is given the following data expressed in a Prolog-like syntax:

```
customer(X),profession(X,accountant),
lives_in(X,cleveland),buys(X,300).

customer(X),profession(X,lawyer),
lives_in(X,beverly_hills),buys(X,25000).

customer(X),profession(X,accountant),
lives_in(X,beverly_hills),buys(X,30000).
```

The data-driven learner would extract what is common to these expressions and give the following generalization:

```
customer(X),lives_in(X,beverly_hills),
buys(X,Z) and Z >= 25000.
```

This example uses one of the simplest generalization rules, referred to as the dropping condition rule. According to this rule, in order to generalize a conjunction you may drop some of its conjunctive conditions.

MODEL-DRIVEN LEARNERS

A model-driven learning program is characterized by its hypothesis forma-

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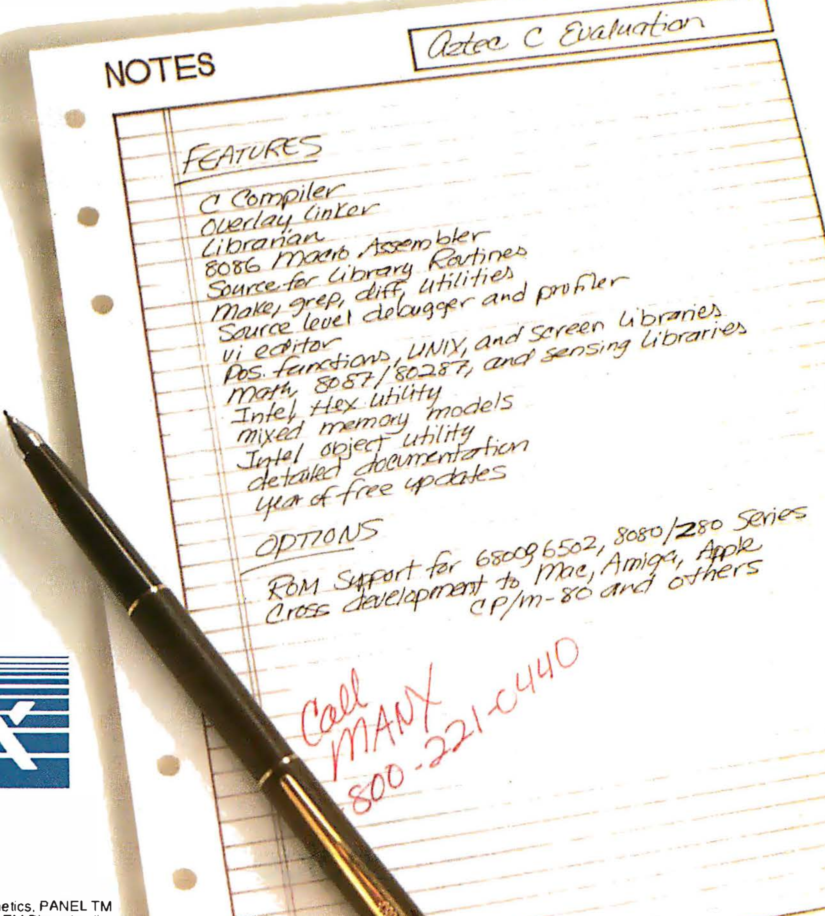
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tion. Such programs form hypotheses that are then tested for verification against available data or through the assistance of the trainer.

From a general standpoint, the algorithm for a model-driven learner looks like this:

begin: develop a hypothesis
while hypothesis does not satisfy target concept *do* try another hypothesis that is more general or more specific depending on how the trial concept relates to the target concept.

Marvin's hypothesis formation differs from most other model-driven learners by taking advantage of what it already knows. Learned concepts that reside in memory are used to learn more complex concepts. Marvin develops concepts in much the way a human would; that is, the repertoire of concepts grows hierarchically.

Expert Systems

The expert systems applications at work today perform quite well in a limited domain and for routine rules of thumb in most cases. Enter the slightest novelty and deviation from the programmed knowledge and users get such discouraging answers as "This parameter has not been defined." Worse yet, the system cannot learn the new concept or relationship. Users are quickly frustrated by the expert system when they notice the wasteful paths it takes time after time trying to prove the same thing, not being able to improve on its problem-solving strategies, and, most important, not being able to learn from past errors. The knowledge-acquisition bottleneck can be eliminated by letting the expert system learn both rules and concepts in a more automated fashion. Such a system should also have the ability to acquire control techniques for optimizing its own processing. There are encouraging developments in all of these areas.

There is a danger that I may be overselling the automated part of learning and underestimating the difficulties involved. I would like to stress a simple point: For what the machine learns to be relevant it is necessary that humans stay close to the learn-

ing process. Also, for what is learned to be useful it must be scrutinized before it is used. This latter point is referred to by R. S. Michalski (reference 3) as the "comprehensibility principle." As for the question of relevance, even if you consider the seemingly simple case of inductive generalization, you immediately discover that a number of background assumptions go into the choice of direction along which generalization takes place. Paul Utgoff and T. Mitchell (references 4 and 5) use the term "bias" to describe that part of a learning program "which influences how the concept learner draws inductive inferences based on the observed training instances." It is impossible to capture in a computerized system all the human constraints and intentions, those apparent as well as the tacit. To assure greater cooperation between machine and humans in the process of learning, the system must display a good deal of transparency effected through flexible explanatory facilities.

MARVIN: A PROGRAM THAT LEARNS TO LEARN

Marvin, a machine learning program developed by C. Sammut (reference 6), pays heed to Banerji's suggestions for a language capable of growth. The description language that is used for Marvin is a subset of Horn clause logic. This language makes the learning and execution of a concept fairly easy because the concept is described in terms of a logic program.

Marvin depends on a human trainer to supply hierarchically structured sets of examples. The trainer presents Marvin with examples of a concept to be learned (the "target concept"), and Marvin generalizes a hypothesis (represented by a "trial concept") from the given examples. The search strategy that Marvin employs to capture the target concept is specific-to-general (i.e., starting from each example, the program creates a new trial concept that is a further generalization of the first example). To find out whether the hypothesis is a proper one, Marvin comes up with objects that are adequately described by the trial concept. These objects are in turn

(continued)

```
What is the name of the concept? letter
Show me an example of letter: "A"
X is a letter if:
X is "A"
Show me an example of letter: "B"
X is a letter if:
X is "B"
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Show me an example of letter: "Z"
X is a letter if:
X is "Z"
Show me an example of letter: no
X is a letter if:
X is "A"
or X is "B"
. . . . . . . . . .
or X is "Z"
Do you want to teach me another concept? yes
What is the name of the concept? letter_list
Show me an example of letter_list: [ ]
X is [ ]
Show me an example of letter_list: [A]
The head of X is "A"
The tail of X is [ ]
"A" is an instance of a letter.
The description can be generalized to:
The head of X is a letter
The tail of X is [ ]
Is [B] also an instance of a letter_list? yes
[ ] is an instance of letter_list.
The description can be generalized to:
The head of X is a letter
The tail of X is a letter_list
Is [B A] an example of letter_list? yes
Show me an example of letter_list: no
The description of letter_list is:
X is a letter_list if:
X is [ ]
or
The head of X is a letter
The tail of X is a letter_list.
Do you want to teach me another concept? yes
What is the name of the concept? append
Show me an example of append: ([ ],[A],[A])
X1 is [ ]
The head of X2 is "A"
The tail of X2 is [ ]
The head of X3 is "A"
The tail of X3 is [ ]
[ ] is an instance of a letter_list.
The description can be generalized to:
The head of X2 is "A"
The tail of X2 is [ ]
The head of X3 is "A"
The tail of X3 is [ ]
X1 is a letter_list
Is ([A],[A],[A]) an instance of append? no
"A" is an instance of a letter.
The description can be generalized to:
X1 is [ ]
The tail of X2 is [ ]
The head of X3 is "A"
The tail of X3 is [ ]
The head of X2 is a letter
Is ([ ],[B],[A]) an instance of append? no
The head of X2 is the same as the head of X3
The description can be restricted to:
X1 is [ ]
The tail of X2 is [ ]
The tail of X3 is [ ]
The head of X2 is a letter
The head of X3 is the same as the head of X2
Is ([ ],[B],[B]) an instance of append? yes
[ ] is an instance of letter_list.
The description can be generalized to:
X1 is [ ]
The tail of X3 is [ ]
The head of X2 is a letter
The head of X3 is the same as the head of X2
The tail of X2 is a letter_list
Is ([ ],[B A],[B]) an instance of append? no
The tail of X2 is the same as the tail of X3
The description can be restricted to:
X1 is [ ]
The head of X2 is a letter
The head of X3 is the same as the head of X2
The tail of X2 is a letter_list
The tail of X3 is the same as the tail of X2
Is ([ ],[B A],[B A]) an instance of append? yes
The description can be rewritten as:
X1 is [ ]
X2 is a letter_list
X3 is the same as X2
Show me an example of append: ([A],[B],[A B])
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
The tail of X1 is [ ]
The head of X1 is a letter
The head of X3 is the same as the head of X1
X2 is a letter_list
The tail of X3 is the same as X2
Is ([B],[ ],[B] an instance of append? yes
([ ],X2, tail of X3) is an instance of append
The description can be generalized to:
The head of X1 is a letter
The head of X3 is the same as the head of X1
(tail of X1, X2, tail of X3) is an append
Is [B A],[B],[B A B]) an instance of append? yes
The description of append is:
(X1,X2,X3) is an instance of append if:
X1 is [ ]
X2 is a letter_list
X3 is the same as X2
or
The head of X1 is a letter
The head of X3 is the same as the head of X1
(tail of X1,X2,tail of X3) is an append
```

Figure 1: *A session with the model-driven learner Marvin, wherein the trainer teaches Marvin the concepts letter, letter_list, and append. It is up to the trainer to present these concepts to Marvin in a hierarchical fashion. Note about append:* Append *joins a new* letter_list *onto the end of an existing* letter_list *so in the example of append,* ([A],[B],[A B]), *the* letter_list [B] *is appended onto the* letter_list [A], *resulting in the new* letter_list [A B].

presented to the trainer.

If the trainer decides that the object is contained in the target concept (such an object is referred to as "consistent"), Marvin attempts a further generalization. If, however, the trainer decides that a particular object is not contained in the target concept (such an object is called "inconsistent") and there are no other possibilities for generalizing, Marvin takes into account the error of overgeneralizing and creates a new trial concept that is more restricted. A concept has been learned when all possibilities for generating trial concepts have been exhausted.

Marvin is composed of the following components:

- A description language.
- An intepreter. This interpreter for Marvin's language must recognize objects described by a concept and generate instances of the concept.
- An associative memory.
- A generalization procedure. This procedure creates a more general description once it is given a concept.
- A learning strategy. Marvin begins with an initial hypothesis and continues applying the generalization procedure until the target concept is learned.

The learning algorithm forms hypotheses that are tested for verification against available data or through the assistance of the trainer. The learning algorithm is given as follows:

1. Initialize. The example given by the trainer is described in a form of clausal logic. This makes up the initial hypothesis.
2. Generalize. Attempts are made to further generalize. If these attempts are proved unsuccessful, the learning process stops.
3. Test. The generalization is tested by constructing an object from the trial concept. If the trainer finds the object consistent, then go to 2.
4. Restrict. If the trial concept contains objects that are not to be found in the target concept, a more specific hypothesis is created. Go to 3.

THE DESCRIPTION LANGUAGE

Following Prolog, Marvin represents concepts using Horn clauses, that is, expressions of the form Q(X) <-- P(X) & R(X). The basic constructs of these expressions are predicates like father(X,Y), interpreted as X is the father of Y. The choice of Horn clause logic means you can use a uniform way of describing sets of objects and relations among objects. Also, since concepts are represented as sets of Horn clauses, they can be executed as logic programs.

Suppose you want Marvin to learn the concept of New Yorker as a more specific case than that of a Manhattan resident. The concept could be given as

```
new__yorker(X) <-- human(X) &
        resides__in(X,manhattan) &
        walks__nervously(X).
```

While at work to learn concepts Marvin uses two types of memory: a long-term memory that is a database of descriptive Horn clauses like the one above and a short-term memory that contains only facts, that is, instantiated predicates like resides__in(francois,paris). The short-term memory contains descriptions of the trainer's examples. Such an example might look like this:

```
human(koch).
resides__in(koch,manhattan).
walks__nervously(koch).
```

A SESSION WITH MARVIN

Figure 1 shows the transcript of a session with Marvin where the trainer teaches Marvin the concepts of letter, letter__list, and append in that order.

At the outset, a distinction should be made between the syntactic repertoire of Marvin, which includes primitive constructs of lists, and semantic representations. Marvin's syntactic repertoire includes the properties of head and tail, which are separate from the concept of the semantic notion, list. Marvin has the ability to recognize when two objects are the same.

All concepts known are contained in Marvin's memory, which at the beginning of the session is empty. The trainer painstakingly gives Marvin every example of a letter and indicates that there are no other examples by replying to Marvin's query for another example of a letter with "no." Marvin then presents its concept of a letter and asks if the trainer wants to teach it any other concepts. The interactive session continues with Marvin, and two incrementally more sophisticated concepts are learned, those of letter__list and append.

CONCLUSION

Professor Banerji and his colleagues of the Machine Learning Laboratory at St. Joseph's University are working on languages that are characterized by self-enrichment. One matter of particular interest is the way research in this area can be useful in future Prolog implementations that incorporate intelligent backtracking techniques. In a joint venture, the State of Pennsylvania through its Ben Franklin Partnership, St. Joseph's University, and Orphic Experts Inc. are in the process of developing learning programs that could prove of significance as enhancements for expert systems in the defense area in particular.

Finally, from what has been said in the course of this article you might get the feeling that I should be talking about machine-aided learning rather than machine learning. This goes along with the realization that despite the growing sophistication of its use, the computer remains just a tool for humans, at least for now. ■

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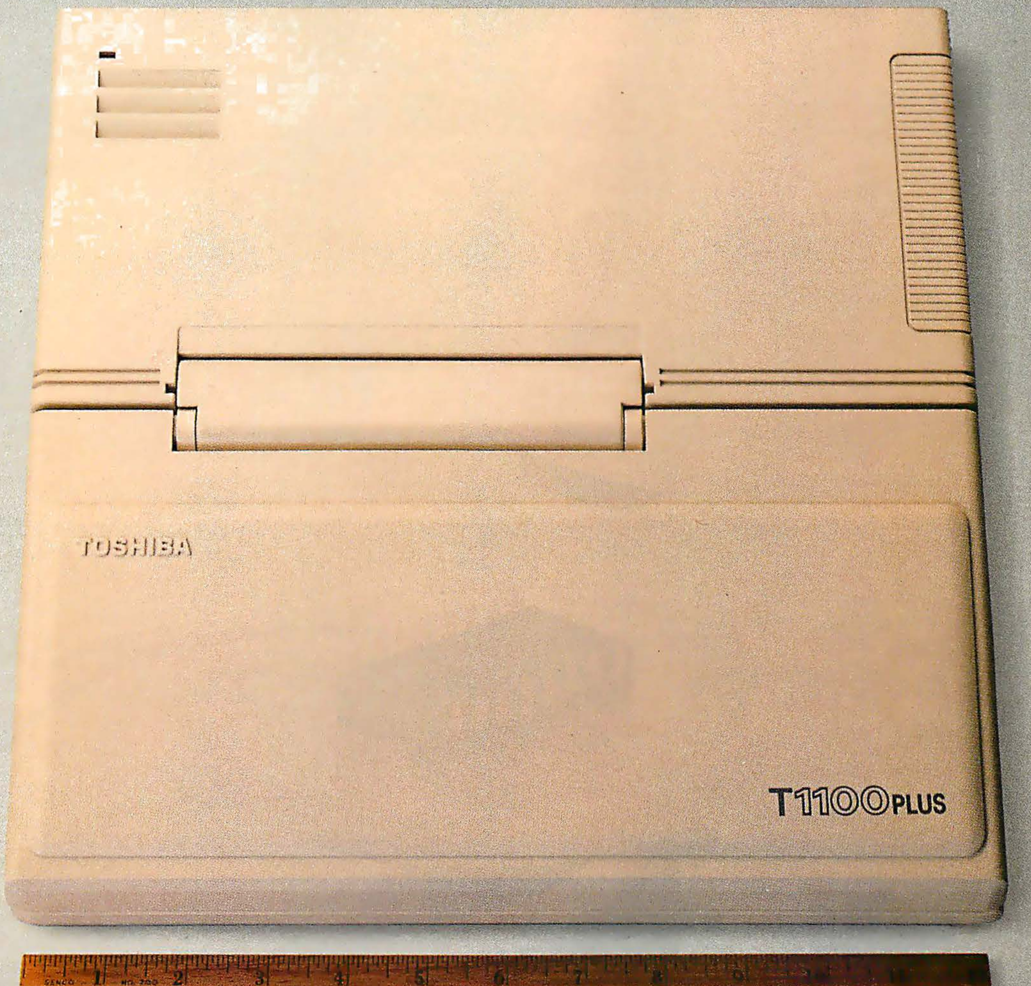
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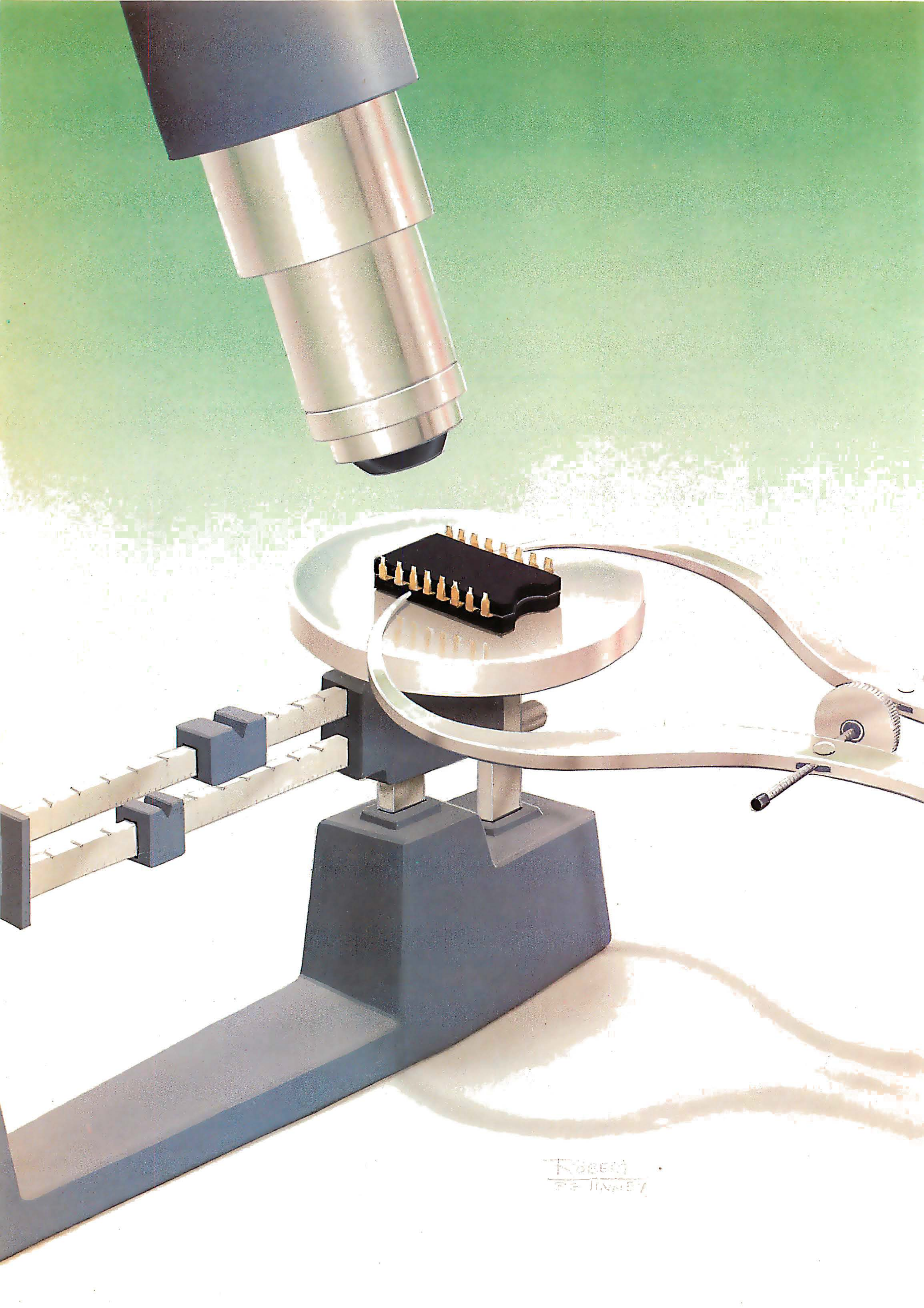
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Reviews

JOHN D. UNGER reviews three IBM PC clones: the Kaypro PC, the Epson Equity I, and the Multitech MPF-PC/700. He compares their performance and functionality, and he notes that although the hardware designs are markedly different, all three emulate the IBM PC well. He found the Kaypro PC to be the best value, while the MPF-PC/700's faster clock speed accounts for its high performance.

Chris Crawford examines the Macintosh Plus. He concludes that the computer solves most of the problems inherent in the original 128K-byte Macintosh by virtually eliminating disk swapping and providing more disk storage and RAM space. He and Tom Thompson, a BYTE technical editor, also compare four memory-expansion kits for the Macintosh Plus.

Robert D. Swearengin looks at three 24-pin dot-matrix printers. All three are fast, versatile, and provide excellent quality, but Robert notes that there is a wide range in functionality and price.

Eldon D. Hearn surveys eight digitizers. A single table summarizes the features and capabilities of the devices. The article explains the table and also provides information that should prove essential before you purchase a digitizer.

Charlie Heath compares two popular C compilers for the Amiga. Both Lattice C and Manx Aztec C68K have strengths and weaknesses, and either should suit your needs, but the Aztec C68K compiler scored well in the benchmarks. Charlie also praises the C68K compiler for providing source code for the library functions and for generating more compact code.

Jeffrey M. Jacques examines SPSS/PC+, an analytical software package. Jeffrey has found that the package provides a substantial but incomplete subset of SPSS-X, the mainframe version. He concludes that the package does almost everything you might want it to do, and at a reasonable price.

Warren Block was among the first to use Aegis Animator and Aegis Images. His review reveals that the Amiga is getting the fine software that its hardware deserves.

Ross Ramsey compares Turbo Lightning and Strike. Both products provide RAM-resident spelling checkers that correct your spelling as you write. Ross has found that, at least for him, the programs are less useful and more annoying when used with longer documents. Strike is less expensive, but you may require some or all of Turbo Lightning's options.

Finally, Richard Harkness recommends filePro 16 and filePro 16 Plus, two PC-DOS and MS-DOS relational database management systems. He notes that both are fast, flexible, and worth a long look.

R·E·V·I·E·W·E·R'S N·O·T·E·B·O·O·K

The MacWorld Expo in Boston was a big hit. The crowds were vibrant, and there were many impressive developments. The most obvious of these were in desktop publishing. Packages such as PageMaker (Aldus Corporation, 411 First Ave. S, Suite 200, Seattle, WA 98104, (206) 622-5500) and MacPublisher II (BSPI, 1260 Boylston St., Boston, MA 02215, (800) 556-0027) were in evidence, but they will undoubtedly be even more effective when they are marketed with larger screens for the Macintosh.

At the Expo we saw one such screen, The Big Picture from Levco (6160 Lusk Blvd., San Diego, CA 92121, (619) 457-2011). This upgrade for the Macintosh Plus or the 512K-byte Macintosh provides a 17-inch display with a 1024- by 808-pixel grid. It wasn't hard to imagine typesetting two facing pages simultaneously on this screen and future versions of the page-composition systems. To install The Big Picture, you connect a display controller to the 68000 with a clip-on connector.

IDT Systems (301 Bronxville Rd., Bronxville, NY 10708, (914) 968-7647) supplies MegaScreen, a video peripheral system for the Macintosh Plus with 1024- by 1024-pixel resolution. MegaScreen also uses an internally installed card. Both units provide 128K bytes of on-board video memory, and both manufacturers claim full compatibility with Macintosh software.

The most interesting application that we saw at the Expo was the latest version of FullPaint from Ann Arbor Softworks (308½ South State, Ann Arbor, MI 48104, (313) 996-3838). The application, which requires at least 512K bytes of memory to operate, allows you to paint on the entire screen and on up to four documents at the same time. You can therefore cut and paste among several documents, and FullPaint is fully upward-compatible with MacPaint files. The program is also compatible with Switcher, digitizing tablets, and digitizing cameras.

The SCSI port on the Macintosh Plus is responsible for the proliferation of third-party hard disks for the computer. Perhaps the most interesting of these is the drive from ProApp (1475 South Bascom Ave., Suite 101, Campbell, CA 95008, (408) 559-3552), which you can also connect to a variety of other Apple computers, including the IIe, the IIc, and the earlier 128K- and 512K-byte Macintoshes. The drive hooks directly to the SCSI port, but you can also connect it to the floppy disk port on an Apple II. The best feature of the hard disk is that you can partition the drive to accommodate both a Macintosh Plus and an Apple IIe or IIc.

For the Amiga, I looked this month at MaxiPlan, a powerful spreadsheet from MaxiSoft (2817 Sloat Rd., Pebble Beach, CA 93953, (408) 625-4104). The software makes full use of the Amiga's environment. It supports multitasking, and with the mouse you can easily select and drag on cells, select the numerous options from standard pull-down menus, and generate full-color charts in a variety of styles and formats. Additional features allow you to easily use the application as a database manager, and the program has voice support for the blind.

Highways and Byways from New Directions Software (5259 Sepulveda Blvd., Suite 9, Van Nuys, CA 91411, (818) 784-9354) caught our attention. For IBM PC compatibles, the software allows you to plan your automobile trips and keep track of expenses quickly and effectively. There will be three regional maps for use with the program (at press time only the western map was available, but the company says that central and eastern maps will be out by the end of the year), each for $49.95. It was easy to generate routes, and I was impressed that the algorithm generated the same route regardless of whether I went from point A to point B or from point B to point A.

The software lists the route with reasonable directions, and you can obtain an estimate of how much time is involved. You can also vary a number of parameters including the season and the type of car you drive, and you can optimize the route for either time or distance. The product seems well suited for long-distance routing. Localities are not finely mapped, however.

Last month I discussed my working environment. Since then, I have added Cruise Control from Revolution Software (715 Route 10 E, Randolph, NJ 07869, (201) 366-4445), which Ezra Shapiro discusses in his column this month. I can also report that the software performs extremely well. At the DOS level and with PC-Write, my favorite word processor, the cursor moves about three times faster. More importantly, perhaps, I encountered no incompatibilities with any of my other RAM-resident software.

Also amazing is WildFire, a Zenith Z-151/-152/-161 speed kit from Software Wizardry (1106 First Capitol Dr., St. Charles, MO 63301, (314) 946-1968). The kit includes a V20, a plug-in daughterboard, and a new chip set that Software Wizardry claims will outperform a Z-158 at 8 MHz. I will install it this month in our Z-151 and report next month on the "new" system's performance.

—Jon Edwards
Senior Technical Editor, Reviews

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Three IBM Clones

BY JOHN D. UNGER

A trio of IBM PC *clones from* Kaypro, Epson, *and* Multitech

Three new IBM PC XT clones have recently appeared on the already crowded IBM PC clone market. Two are from longstanding computer hardware manufacturers Kaypro and Epson. The third clone, manufactured by Multitech, comes from Taiwan.

The $1595 Kaypro PC is the only desktop IBM PC compatible that Kaypro is currently marketing. The Epson that I reviewed is the $1295 Equity I. I also reviewed the $1230 Multitech MPF-PC/700 D1.

I am intrigued by the different hardware approaches used by the three manufacturers to achieve compatibility with the IBM PC. Both the hardware design and the component layout vary markedly from computer to computer. However, the net results are similar, and all three micros emulate the IBM PC well.



The Multitech and Epson machines were limited in the amount of software that I could check for compatibility because they use the equivalent of IBM's monochrome adapter board and display. The Kaypro PC also has a monochrome monitor, but its multivideo board can display colors in shades of green as well as emulate the monochrome display of the IBM PC.

All three computers come with two 360K-byte double-sided double-density disk drives and 256K bytes of RAM. The Kaypro and Epson systems include a monochrome monitor, but Multitech did not include a monitor with the MPF-PC/700 that I reviewed; therefore, the Epson's monitor performed double duty during the review. All the systems included the MS-DOS 2.11 operating system. The Kaypro PC comes bundled with an impressive array of MicroPro software (see page 240), and the Multitech system includes an intriguing optional operating system, Concurrent CP/M. Both the Multitech and the Kaypro systems would be suitable for use as small business or home computers, but the Epson system, because of its limited expansion capability and small power supply, would be better in a home environment.

Display

The Kaypro PC comes with its own multivideo board, which gives you the option of using three outputs: monochrome, RGB, and composite video. A memory-resident utility program lets you switch between monochrome and color modes. The default mode at start-up is set by DIP switches on the video board. A green monochrome monitor comes standard with the Kaypro PC. This monitor uses a high-persistence phosphor that leaves a faint but noticeable ghost image on the screen when you scroll through text or play certain games.

You can run graphics programs that use color on this system; the colors are displayed as shades of green. The Multitech MPF-PC/700 has a standard CGA (color graphics adapter) board but no monitor. I did not have a monitor compatible with this type of video adapter, but Multitech provided me with a monochrome adapter that I was able to use with the Equity I's monitor. [*Editor's note: The Multitech MPF-PC/700 now includes a high-resolution soft-white (K171 phosphor) 12-inch monochrome monitor in its standard configuration.*]

The Equity I has a monochrome display board and monitor. This combination displays only text and the IBM graphics characters.

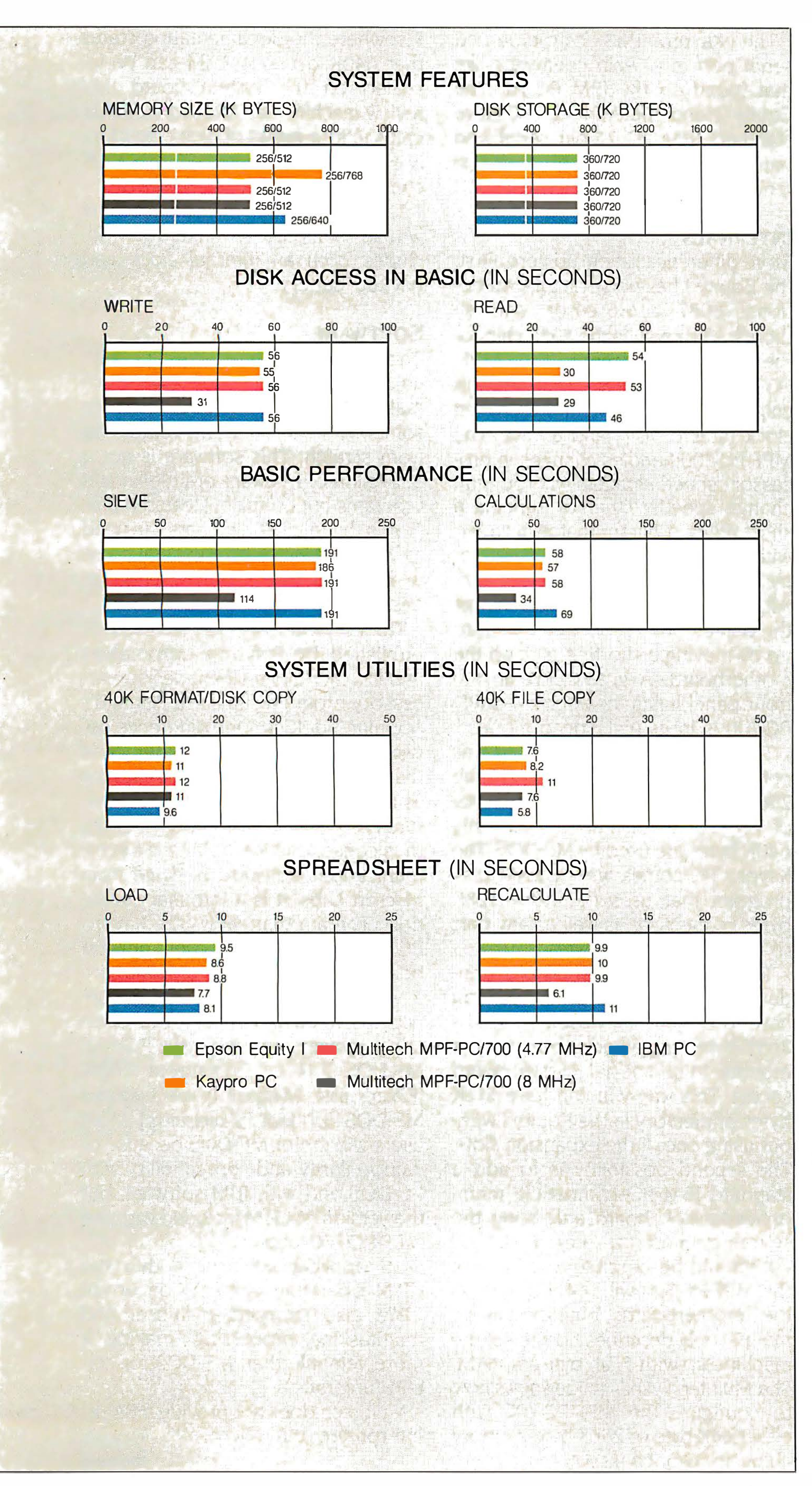
Keyboard

Both the Equity I and the Kaypro PC have IBM PC AT–style keyboards. The Kaypro PC's is complete with a System Request key, lighted indicators for the Caps, Scroll, and Num Lock keys, and it has a keyboard lock on the front

(continued)

John D. Unger (P.O. Box 95, Hamilton, VA 22068) *is a geophysicist for the U.S. government who writes graphics software and uses computers to study the structure of the earth's crust.*

Name	Kaypro PC	Equity I	MPF-PC/700 D1
Company	Kaypro Corporation 533 Stevens Ave. Solana Beach, CA 92075 (619) 481-3900	Epson America Inc. Computer Products Division 2780 Lomita Blvd. Torrance, CA 90505 (213) 539-9140	Multitech Electronics Inc. 1012 Stewart Dr. Sunnyvale, CA 94086 (800) 538-1542
Size	19½ by 16 by 6 inches 30 pounds	14½ by 15 by 6 inches 23 pounds	17½ by 16½ by 6 inches 27½ pounds
Components			
Processor:	8088 at 4.77 MHz	8088 at 4.77 MHz	8088-2, switchable between 4.77 and 8 MHz
Memory:	256K bytes dynamic RAM (standard); expandable to 640K bytes on motherboard	256K bytes dynamic RAM (standard); expandable to 512K bytes on motherboard	256K bytes dynamic RAM (standard); expandable to 640K bytes on motherboard
Mass storage:	Two Canon MDD 531 360K-byte double-sided double-density 5¼-inch drives	Two Epson SD-500 360K-byte double-sided double-density 5¼-inch drives	Two Panasonic 360K-byte double-sided double-density 5¼-inch drives
Display:	High-resolution green monochrome 12-inch diagonal screen; compatible with IBM monochrome adapter and IBM color graphics adapter; composite, RGB, and monochrome video output connectors	High-resolution green monochrome 12-inch diagonal screen; monochrome display adapter (IBM compatible)	High-resolution soft-white 12-inch diagonal screen; color graphics adapter (IBM compatible)
Keyboard:	Detached QWERTY with 84 keys including 10 function keys and numeric keypad	Detached QWERTY with 83 keys including 10 function keys and numeric keypad	Detached QWERTY with 97 keys including 10 function keys, separate cursor keys, and numeric keypad
Expansion:	Three full-length and three half-length slots	Two full-length slots	Four full-length slots
I/O interfaces:	One RS-232C serial port (9-pin); one Centronics-compatible parallel printer port (25-pin); speaker (accessed from BASIC or assembly language)	One RS-232C serial port (25-pin); one Centronics-compatible parallel printer port (25-pin); speaker (accessed from BASIC or assembly language)	One RS-232C serial port (25-pin); one Centronics-compatible parallel printer port (25-pin); speaker (accessed from BASIC or assembly language)
Software	MS-DOS 2.11; GW-BASIC; WordStar; MailMerge; CorrectStar; StarIndex; PolyWindows Desk; Mite	MS-DOS 2.11; GW-BASIC	MS-DOS 2.11; Concurrent CP/M; MASM (Microsoft Macro Assembler)
Documentation	MS-DOS 2.11 user's guide, MS-DOS 2.1 programmer's reference manual; GW-BASIC 2.0 manual; software manuals for WordStar, MailMerge, CorrectStar, StarIndex, PolyWindows Desk, and Mite	User's guide; MS-DOS manual; GW-BASIC manual	MS-DOS 2.11 user's and reference guides; Concurrent CP/M user's and reference guides
Price	$1595	$1295	$1230



panel. The Equity I's keyboard lacks these features. The MPF-PC/700's ASCII keys are laid out similarly to the PC XT's, but the left Shift key is easier to reach and there is a larger Return key. The MPF-PC/700 also has a convenient separate cursor keypad located between the main keyboard and the numeric keypad. Heavy spreadsheet users will appreciate this arrangement. The feel of all three keyboards was good, but none has an audible click like the IBM keyboards. My favorite is the Equity I's, which is somewhat firmer than the other two, but I found no strong shortcomings with any of them.

Hardware and Layout

Both the Kaypro PC and the Multitech MPF-PC/700 are similar in appearance to IBM machines. The Kaypro PC is almost a duplicate of the PC AT, even down to the keyboard lock on the front panel. The Multitech MPF-PC/700 resembles the PC XT except for its color scheme and the hardware reset switch on the front panel.

The Epson Equity I has a much smaller footprint and more attractive styling than the other two machines. Epson uses flip-down panels on the front of the main unit. The on/off switch is behind one panel at the top right, and a larger panel beneath the disk drives conceals a hardware reset button and ten DIP switches that you use to configure the amount of RAM, the type of monitor installed, the number of floppy disk drives in the system, and whether the parallel and serial ports are enabled or disabled.

At first examination, all three computers seem to use a basic IBM-like layout for their internal components. However, a closer look reveals some important differences. The Equity I's small size means that internal components are tightly packed and there is room for only three expansion slots. Only two are available after a video board is installed. There is room for only two half-height disk drives, one of which can be replaced by a half-height hard disk, and they must be removed for access to the motherboard components, microprocessor chip, and RAM.

(continued)

The Equity I's power supply is rated at only 55 watts. Normally this would limit expansion capability, but since the machine has only three internal slots, the low power output is not critical.

The MPF-PC/700's layout is similar to a standard IBM PC XT's except that the two floppy disk drives are mounted on the removable top cover of the case rather than on the main frame of the unit. You have to handle the cover carefully when removing it because of the umbilical wires connected to the main unit. Both the MPF-PC/700 and the Kaypro PC have space on the main chassis to add an internal full-height hard disk drive in addition to the two standard half-height floppy disk drives.

The Kaypro PC's layout superficially resembles the IBM PC's. However, the Kaypro PC's motherboard is used only as a mount for the expansion slots. The microprocessor and its accessory chips reside on one full-length expansion card, and the RAM, disk controller circuits, and I/O ports are on another. A third full-length slot is taken up by the Kaypro PC's multimode video board. This layout still leaves three full-length and three half-length slots free for further expansion.

Putting the microprocessor and its ancillary chips on an expansion card makes the Kaypro PC instantly upgradable and is a guarantee against obsolescence. In fact, Kaypro is now advertising an 80286 processor replacement board that turns the Kaypro PC into an IBM PC AT clone. The only catch is that the Kaypro has an 8-bit data path between the processor board and RAM board because the expansion slots on the Kaypro PC are compatible with the IBM PC rather than with the AT's 16-bit data path. This degrades performance somewhat because the 8-bit bus needs more clock cycles to send the same information between the microprocessor and memory.

The hardware reset switch for the Kaypro PC is mounted on the microprocessor expansion board at the rear of the computer. It is more awkward to reach than the front-mounted reset switches on the Equity I and the Multitech MPF-PC/700.

The Kaypro PC's card-mounted serial port is a 9-pin connector like that found on the IBM PC AT. The Equity I and the MPF-PC/700 have standard IBM PC 25-pin serial and parallel ports mounted on their system motherboards.

INTERNALS

More differences show up here. First, the Equity I has no socket for an optional 8087 coprocessor, and although all three use the 8088 chip for their microprocessors, the MPF-PC/700 uses the 8088-2 version of this chip. This allows switching between clock rates of 4.77 and 8 MHz. The MPF-PC/700 handles changes in processor speed gracefully. You can change speeds either by running a short utility program that is included with the operating system software or by simultaneously pressing the Ctrl, Alt, and plus (+) keys. You can change the default processor speed at start-up by moving a shorting plug on the motherboard. A green LED on the front panel lights up when the MPF-PC/700 is in its high-speed mode.

The Kaypro PC that I reviewed was configured with three banks of nine 256K-bit RAM chips. This gives a total of 768K bytes of memory, but only 640K bytes are used by MS-DOS. The Kaypro PC comes with a RAM disk program that uses the extra 128K bytes of memory as well as any part of the regular 640K bytes.

To add memory beyond the standard 256K bytes in the Equity I, you have two options. Epson makes a 265K-byte piggyback board that mounts in a special system-board socket. This way you can have 512K bytes of memory in the Equity I without using one of the expansion slots. The second possibility is to add a standard IBM PC-compatible memory-expansion board and bring the system memory up to 640K bytes.

It should be possible to configure the MPF-PC/700 with 640K bytes on the motherboard, but the user's manual only describes how to set the machine up with 512K bytes of RAM. The Multitech user's guide shows how to configure the MPF-PC/700 with either 64K-byte or 256K-byte memory chips in two banks of nine chips. Elsewhere the documentation states that 640K bytes of RAM can be installed on the system board. My review machine had room for 36 RAM chips in four banks of nine chips. Only one bank was populated with 256K chips.

The Kaypro PC is the only machine whose standard configuration includes both an internal clock and backup battery.

SOFTWARE

The Kaypro PC comes bundled with an impressive array of software, which makes this micro a good value for someone who is starting computing from scratch. This software is not a collection of freeware or little-known programs but useful, full-featured programs that almost eliminate the need to buy anything else for general home or business use. The only program missing is a spreadsheet.

The PolyWindows Desk software is published by Polytron Corporation and is a memory-resident desktop accessory program similar to Borland's popular SideKick. One difference between PolyWindows and SideKick is that you can choose to load as few or as many of the memory-resident features as you want with PolyWindows, thus conserving RAM. Mite is a communications software package from Mycroft Labs. It is a terminal emulation program that allows the Kaypro PC to communicate over bulletin boards and with other computers.

Multitech gives you the unusual option of choosing between two operating systems for the MPF-PC/700: MS-DOS 2.11 or Concurrent CP/M. [*Editor's note: Multitech is now supplying* MS-DOS 3.1 *with its computers.*] Most users will prefer MS-DOS because of its popularity and compatibility with PC-DOS and with IBM software, but the version of CP/M included with the MPF-PC/700 allows you to run MS-DOS applications from within the CP/M operating system. Concurrent CP/M also supports multiuser and multitasking processing, making it more versatile than MS-DOS for certain functions.

Multitech does not provide a BASIC interpreter, but Microsoft's MASM,

(continued)

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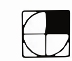
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*as reported in Micro Cornucopia, August-September 1985. Turbo Pascal is a registered trademark of Borland International.

LINK, CREF, and EXE2BIN programs for assembling and linking assembly language programs are included with the MS-DOS utility software.

The Equity I is bundled with MS-DOS 2.11 and GW-BASIC. As part of the operating system utilities, Epson provides menu-driven programs that format and copy disks and configure the serial port.

PERFORMANCE AND COMPATIBILITY

As the benchmark graphs show, there were no big surprises when the BYTE benchmark tests were run on these three micros. The results are similar to those obtained for the IBM PC. The exceptions are for the MPF-PC/700 running in its 8-MHz mode and for the Kaypro PC's BASIC Disk Access Read test. The former results are easily understood, but the Kaypro's increased performance in the Read test is less easy to decipher. It may be due to the way that the machine's file-read BIOS function is written.

In terms of day-to-day performance, you would not notice very many differences while using any of the three computers unless you had the MPF-PC/700 in its high-speed mode all the time. I had no problems running any of my IBM software in the 8-MHz mode.

All three micros are highly compatible with the IBM PC. Kaypro uses the well-known ROM made by Phoenix Software. Both Epson and Multitech have apparently developed their own versions of IBM's ROM.

I could not find any IBM software that would not run on these computers with the exception of games and graphics programs that must run in the color graphics mode. These could not be tested on the Equity I or the MPF-PC/700 because of their monochrome display boards.

As always, you should try your favorite applications program on the computer of your choice before you buy the machine.

DOCUMENTATION

Epson's manuals consist of two 8- by 10-inch three-ring binders that fit into one 5-inch-thick slipcase. The user's guide has clear instructions that help a beginner get the Equity I up and running quickly. The MS-DOS manual is part of the same binder as the user's guide and is about average in terms of completeness and ease of use. The explanation of the operating system commands is clearer and the examples are better than those in the IBM DOS manual. The GW-BASIC manual is adequate.

Multitech includes four slim paperback volumes with the MPF-PC/700. One pair consists of user's and reference guides for MS-DOS 2.11; the other pair offers similar information for Concurrent CP/M.

The operating system manuals are copies of generic Microsoft and Digital Research documents. Much of the information specifically related to the MPF-PC/700 is duplicated in the two user's guides.

As you might expect with all its bundled software, the Kaypro PC has the largest number of manuals. All nine of them are inexpensively bound 7- by 9-inch paperbacks. Although the software manuals included for the MicroPro products are not complete reference manuals, they describe how to use the programs adequately. The manuals for Mite and PolyWindows Desk are written by their respective software publishers. The Mite manual is particularly well written and easy to understand. The presence of an MS-DOS 2.11 programmer's reference manual is a welcome addition for users who will be writing software for the computer.

SUPPORT AND SERVICE

The Equity I comes with a one-year warranty on parts and labor. Epson has a widespread network of dealers throughout the U.S., so obtaining service should not be much of a problem. The compactness of the computer and the difficulty of getting at the main circuit board makes the Equity I harder to work on than the other micros.

The Kaypro PC has a 90-day warranty period that covers all parts and labor. Purchasers are encouraged to have an authorized dealer service the computer, presumably the dealer who sold it. However, you can ship the machine to Kaypro directly. The modular nature of the Kaypro PC makes servicing it easy.

Multitech's U.S. headquarters and service repair facilities are in Sunnyvale, California. They have technical experts on-site to answer owner's questions via a toll-free number. The technical staff proved to be both courteous and helpful when I called with questions concerning the use of some of the operating system utilities included with MS-DOS. The MPF-PC/700 comes with a six-month warranty on parts and labor, but you have to pay for your own shipping. For $40, you can extend the warranty coverage for an additional six months. The computer uses common generic hardware and should be serviceable by any knowledgeable technician.

CONCLUSIONS

The Kaypro PC appears to be the best value of the three computers. Its only shortcoming is the lack of a high-speed (8-MHz) mode like the Multitech MPF-PC/700's. It has adequate internal space and power supply capacity for expansion. One big plus for the Kaypro PC is its removable microprocessor expansion card. This facilitates upgrading of this microcomputer as future options and enhancements become available. But the major advantage that puts the Kaypro PC ahead of the others is the software bundled with it. The actual value of these programs, even priced at discount levels, is in excess of $400.

I found nothing seriously lacking in either the Multitech MPF-PC/700 or the Epson Equity I; they are both good solid IBM PC–compatible clones. Certainly, the Equity I's small footprint makes it well suited to situations where space may be limited.

The Multitech MPF-PC/700 represents a good hardware value for an average IBM PC clone, and its ability to run in an 8-MHz mode makes it the top performer of the trio. The question of how this machine will be marketed and serviced in the U. S. is open to speculation.

The Kaypro PC and Epson Equity I are being discounted fairly heavily, and it would be worthwhile shopping around for either of these machines. ■

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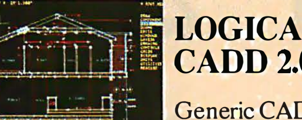
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THE MACINTOSH PLUS

BY CHRIS CRAWFORD

Extra memory and new disk drives correct many of the Macintosh's limitations

The Macintosh has become the most polarizing computer in the industry, attracting ferocious loyalists as well as contemptuous detractors. But even its most ardent boosters have recognized shortcomings in the Macintosh: slow disk drives, lack of expandability, and the high price and slow speed of the hard disk drives designed for the system. Now Apple has released the Macintosh Plus, the first major redesign of the Macintosh.



OVERVIEW

The Macintosh Plus offers new disk drives with twice the capacity of the original Macintosh's (800K bytes versus 400K bytes), internal ROMs twice the size of the original ROMs (128K bytes versus 64K bytes), 1 megabyte of RAM compared to the 128K bytes in the original Macintosh, a new keyboard with a numeric keypad and cursor-control keys, and an SCSI port for hard disk drives. The Macintosh Plus is priced only slightly higher than the original Macintosh: $2599. The system has no slots for expansion boards.

DISK DRIVES

The most important improvement in the Macintosh Plus comes from the new double-sided disk drives, which are faster and quieter. The speed increase is due to the reduction in seek times, which is made possible by doubling the effective size of each track.

The real significance of these new drives is that their capacity now more closely matches the natural demands of the Macintosh system. Consider the disk budget for one of the most common Macintosh applications: document preparation with MacWrite and MacPaint. A System File, Finder, and a good collection of fonts and desk accessories will consume 250K bytes of disk space. MacWrite and MacPaint together take up 130K bytes, leaving only 20K bytes of free space. This is insufficient to handle the system's needs for disk buffering of temporary files. This forces you into a variety of ungainly solutions. My approach was to keep three separate system disks: one for MacWrite, containing lots of fonts; one for MacPaint, with lots of desk accessories; and one for switching between the two, containing few fonts and few desk accessories.

These problems vanish with 800K bytes of disk space. You can keep a huge collection of fonts in all sizes, a hefty pile of desk accessories, MacWrite, MacPaint, Switcher, and a nice Scrapbook, and still have leftover space for system use. The situation in which you create a MacPaint image and transfer it to a MacWrite document via the Clipboard, once a frustrating exercise in disk swapping, is now smooth and trouble-free.

NEW ROMS

The second important improvement in the Macintosh Plus comes from the new ROMs. Their doubled size allowed Apple programmers to make five broad types of improvements. First, the bugs in the old ROMs were corrected. Second, some routines that had been tightly coded in the old ROMs to save space have been recoded so that they consume more ROM space but run faster. Third, the new ROMs include some code that had been bumped out of the old ROMs for lack of space. Fourth, the new ROMs include the code to operate the double-sided disk drives. Finally, some new features have been added, including some new Toolbox calls. The Macintosh Plus can boot from a hard disk, no longer requiring a floppy disk for start-up. A disk cache is provided, which speeds up many operations.

The result of all this is an improvement in the speed of the system. The standard BYTE benchmarks shown on page 248 and the test results in table 1 do not tell the whole story, for a

(continued)

Chris Crawford (5251 Sierra Rd., San Jose, CA 95132) is a freelance computer game designer.

Macintosh Plus

Company
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Size
Main unit: 13½ by 9½ by 11 inches; 16½ pounds
Keyboard: 2½ by 15½ by 6 inches; 2½ pounds

Components
Processor: 68000; 7.8336 MHz
Memory: 1 megabyte of RAM, expandable to 4 megabytes; 128K bytes of ROM; 256K bytes of user-settable parameter memory
Mass storage: One 800K-byte double-sided 3½-inch floppy disk drive
Display: 9-inch black-and-white built-in bit-mapped screen; 512 by 342 pixels
Keyboard: Detachable 78-key with keypad and cursor keys
Pointing device: Optomechanical mouse

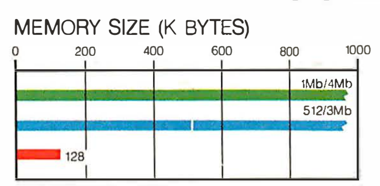
Optional Hardware
800K-byte double-sided 3½-inch external disk drive: $399
Imagewriter II printer: $595

Documentation
Macintosh Plus user's manual

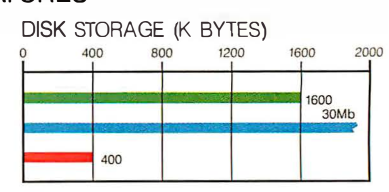
Price
$2599

SYSTEM FEATURES

MEMORY SIZE (K BYTES)

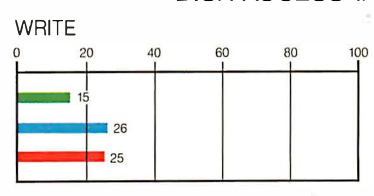


DISK STORAGE (K BYTES)

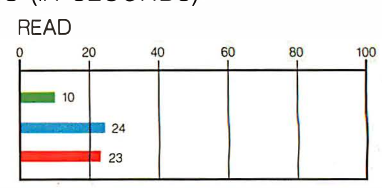


DISK ACCESS IN BASIC (IN SECONDS)

WRITE

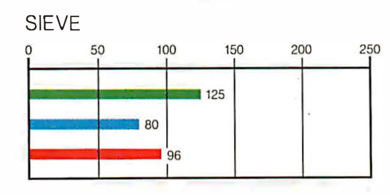


READ

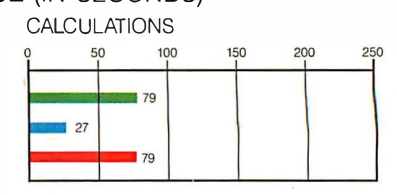


BASIC PERFORMANCE (IN SECONDS)

SIEVE

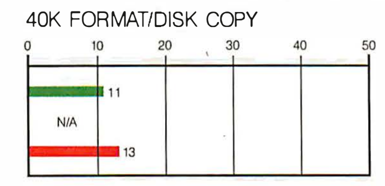


CALCULATIONS

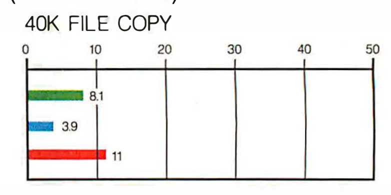


SYSTEM UTILITIES (IN SECONDS)

40K FORMAT/DISK COPY

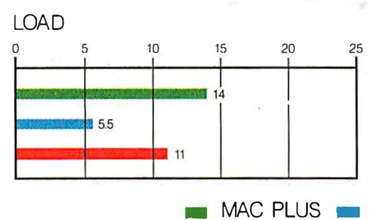


40K FILE COPY

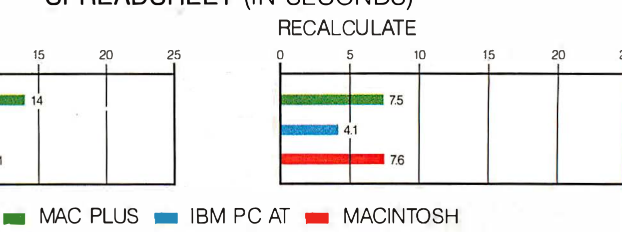


SPREADSHEET (IN SECONDS)

LOAD



RECALCULATE



The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy disk drive and the maximum standard capacity for each system. The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. For the 128K-byte Macintosh, the Sieve was modified to use integer variables, since the conventional Sieve program would not load into memory. The spreadsheet used was Microsoft's Multiplan 1.02. Microsoft BASIC 1.0 was used for the Disk Write and Disk Read benchmarks. On the Macintosh, the Disk Copy program was used for the 40K-byte File Copy benchmark. No Format/Disk Copy tests are done on hard disk systems. System .97 and Finder 1.0 were used for the Spreadsheet and Disk Access benchmarks, and System 3.0 and Finder 5.1 were used for the System Utilities benchmarks.

number of Macintosh-specific features also run much faster now. For example, QuickDraw, the collection of routines for drawing text and images on the screen, now operates from 30 to 500 percent faster than the old ROM version.

SCSI Port

The SCSI port provided with the Macintosh Plus is designed for high-speed data transfer between the Macintosh and its peripherals. It is Apple's second try at its virtual-slot concept. Apple's original concept was too slow and too complex for practical operation. Hard disk drives, the primary target peripheral for the virtual slot, required a great deal of engineering effort to adapt to the virtual slot and performed poorly.

The SCSI port changes this situation. It is a true parallel port rather than a serial port and thus can run at 320K bytes per second as compared with the old virtual slots running at 230K bits per second—11 times slower. The result is that external SCSI hard disk drives attain speeds very close to that of internally mounted hard disk drives.

1 Megabyte of RAM

With most microcomputers, additional RAM has very little value until someone writes software that explicitly takes advantage of that RAM. Fortunately, the Macintosh is blessed with a memory manager that stands between the applications program and the RAM, allocating blocks of RAM as needed. This means that a program designed for a 128K-byte Macintosh can freely use the additional RAM of a Macintosh Plus without any modification. Thus, many Macintosh programs will run faster in the megabyte of RAM that the Macintosh Plus holds. The extra memory can also be used with Switcher, a software RAM disk, or the disk cache. In each case, the speed improvement made possible by all that extra RAM is dramatic.

The real value of the full megabyte of memory, however, will be in its effect on future software development. Good software thrives on lots of RAM. Software makes the machine; programs like MacWrite, MacPaint, Excel, and Helix are the real driving force behind the success of the Macintosh. We will see some truly amazing results when software developers create programs that utilize the full power of a 1-megabyte Macintosh.

Also significant for the Macintosh's future is the easy expandability of the machine to 4 megabytes. The 256K by 1-bit RAM chips are mounted on small circuit boards that plug into the motherboard. When 1-megabyte RAM chips become less expensive, expanding a Macintosh Plus to 4 megabytes will be almost as simple as changing a board on an Apple II. There are already several kits available that expand the Macintosh Plus to 2 megabytes (see the text box "Four Memory-Expansion Kits" on page 250).

Keyboard

Apple offers a new keyboard for the Macintosh Plus. It is very similar to the old keyboard and includes a numeric keypad plus cursor-control keys, the lack of which in the old keyboard had been the source of many criticisms.

I prefer the old keyboard; it takes up less space. The numeric keypad is of no value in my work and pushes the mouse's working area further to the right. The cursor keys are not yet recognized by most Macintosh software except for some Microsoft products. However, if you enter large amounts of numeric data, you will prefer the new keyboard.

Hierarchical File System

Associated with the release of the Macintosh Plus is the new Hierarchical File System (HFS). This replaces the Macintosh File System (MFS). The difference between the two systems lies in the significance of folders. In MFS, a folder is merely a device for visually organizing the files on the desktop. From the point of view of MFS, the files inside a folder are just as accessible as the files on the desktop. Thus, MFS has difficulties keeping track of large numbers of files on a desktop; it consumes inordinate amounts of RAM and runs more slowly.

HFS treats folders as subdirectories whose contents are unimportant unless HFS is specifically directed to examine them. This parsimonious approach to file management is essential when dealing with the large number of files that an 800K-byte floppy disk or a 20-megabyte hard disk can hold.

Compatibility Issues

The release of any new machine generates compatibility problems, which can be either severe or minor. In the case of the Macintosh Plus, the problems seem to be minor.

Some incompatibilities arise with HFS. Programmers who took shortcuts in violation of Macintosh software standards created products that will not operate under HFS. These problems are easily solved, and most of the transgressors have already issued revisions of their software.

Aside from the HFS problems, I was unable to find any software compatibility problems. All of the programs that I tested ran well on the Macintosh Plus. Even the programs with weird copy-protection schemes ran

(continued)

Table 1: A *quick test of system speed is to determine the configuration time to launch MacWrite from the Finder. While this is admittedly not useful as a serious benchmark, it can give a rough idea of the relative performance of the different Macintosh configurations. These timings, all in seconds, are accurate to within one-half of one second.*

Configuration	Seconds
512K Macintosh with floppy disk	24.5
Macintosh Plus with floppy disk and no RAM cache	10.8
512K Macintosh with Apple HD-20 hard disk	10.5
Macintosh Plus with DataFrame 20 hard disk	7.2
Macintosh Plus with 512K-byte RAM cache (preloaded) and floppy disk	5.5
Macintosh Plus with RAM disk	3.7

FOUR MEMORY-EXPANSION KITS

BY CHRIS CRAWFORD AND TOM THOMPSON

Several kits are now available for adding an additional megabyte of memory to your Macintosh Plus (see table A). Installation is simple for anyone who is not squeamish about opening the computer. (The exception is the MacSnap Plus 2 kit, which is sold through a dealer who installs it for you.) The tool required to open the case, a long-handled Torx screwdriver, comes with three of the four kits.

Adding the extra memory is a matter of unfastening the original SIMMs (Single In-line Memory Modules, which are small printed circuit boards with surface-mounted RAM chips) and clipping them onto the expansion kit's boards. In most cases, you'll have to clip a jumper to the Macintosh's address logic chips to complete the procedure. The cramped space inside the Macintosh means that with the extra memory installed, you usually cannot slide the motherboard back into the housing. In these cases you must force, or jump, the board back into its slots using a screwdriver. The exception is The MaxPlus's board, which will slide back into place if you've mounted everything correctly.

Since there are no components to unsolder or traces to cut, these expansion kits can be easily removed, returning the Macintosh to its original condition. (Three of the four kits tested were installed in the same Macintosh Plus at different times.)

All kits provided an additional megabyte of RAM as promised, and no problems were encountered during the normal eight-hour-per-day editorial workload.

Tom Thompson is a BYTE technical editor (One Phoenix Mill Lane, Peterborough, NH 03458).

Table A: *Comparison of features for the four memory-expansion kits.*

Name	Company	Contents of kit	Comments	Price
Plus Plus	Micro Conversions Inc. 1900 East Randol Mill Rd. Suite 103 Arlington, TX 76011 (817) 860-2291	1 megabyte of memory, jumpers, muffin fan, disk of software, Torx screwdriver, installation manual	Software contains Switcher and RAM disk. Motherboard must be jumped into case.	$599
The MaxPlus	MacMemory Inc. 473 Macara Ave. Suite 701 Sunnyvale, CA 94086 (800) 862-2636	1 megabyte of memory, jumpers, piezoelectric fan, disk of software, Torx screwdriver, illustrated installation manual	Software contains RAM disk and print spooler. Motherboard slides into case.	$499
One+One	Levco 6160 Lusk Blvd. Suite C-203 San Diego, CA 92121 (619) 457-2011	1 megabyte of memory, jumpers, piezoelectric fan, illustrated installation manual	No software. No Torx screwdriver. Motherboard must be jumped into case.	$295; Torx screwdriver $5 extra
MacSnap Plus 2	Dove Computer Corp. 1200 North 23rd St. Wilmington, NC 28405 (800) 622-7627	1 megabyte of memory, disk of software, Torx screwdriver, user's manual, illustrated installation manual, grounding strap, clamp to open case	Software contains RAM disk, Switcher, and print spooler. No jumpers needed. No fan. Motherboard must be jumped into case. Dealer installs kit.	$599

well on the new disk drives.

The more serious compatibility problems come from the changes in the hardware. The peripheral sockets have been changed from the old DB-9 connectors to an unusual round connector. Moreover, the pin that supplied 5 volts of power has been removed; this cuts out such peripherals as ThunderScan and MacVision. Peripheral makers have scrambled to correct the problem. If you upgrade your old Macintosh, you may undergo some confusion and frustration trying to get new cables for various peripherals.

COMPLAINTS

Despite all the improvements of the Macintosh Plus, there are still some pitfalls. Why, for example, does a machine with a megabyte of RAM require you to do disk swaps when saving an 8K-byte ASCII file to a third disk, much less the 13 disk swaps I suffered through before hitting the reset button? Why is the new keyboard so high that I still need a palm rest?

A more serious complaint concerns the screen size. I don't refer to the physical size (9-inch diagonal) but rather to the pixel count (171,000), which has become too small for the system. The original Macintosh's screen requires only 21K bytes of RAM for its buffer. This is about right for a 128K-byte machine, as most systems devote about one-eighth of their RAM to screen buffering. However, the 171,000-pixel screen is far too small for a machine with a megabyte of RAM. The small screen has now become the primary limitation of the Macintosh.

TO UPGRADE OR NOT TO UPGRADE?

The owners of regular Macintoshes must now face the question of whether to upgrade their machines. Actually, the problem is tricky, for Apple offers three steps of upgrade: new ROMs and the double-sided disk drive for $299, a new logic board with 1 megabyte of RAM and the SCSI port for $599 for owners of 512K Macintoshes and $799 for owners of 128K-byte Macintoshes and Macintoshes with non-Apple RAM upgrades, or the new keyboard for $129.

I highly recommend the first upgrade to all Macintosh owners. It's inexpensive and gives you the two most important upgraded features of the Macintosh Plus. The improved disk drive alone is worth more than the cost of the upgrade.

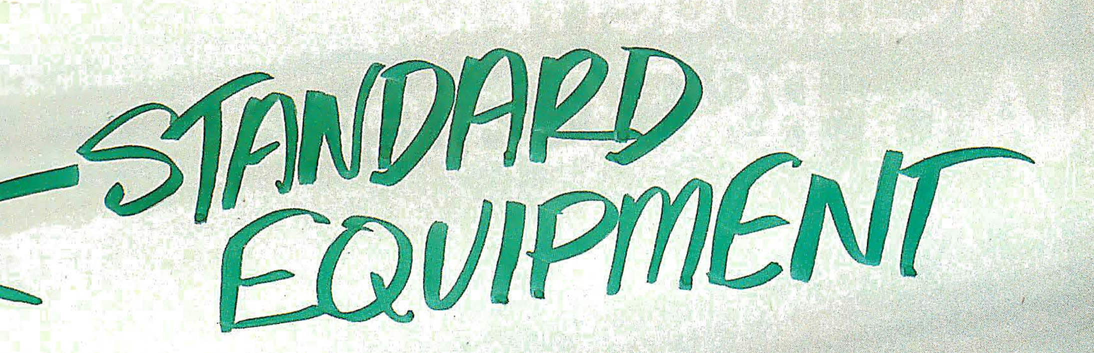
The new logic board is another matter. It is expensive and will not have a great impact on the effectiveness of the machine. Your ideas with respect to hard disks will help you decide. If you already have a hard disk that plugs in through the serial port, it is probably best not to get the new main logic board, as your hard disk will no longer be connectable unless the manufacturer makes some sort of adapter available. If you have no hard disk and plan to get one soon, by all means do get the upgrade, since the SCSI hard disks are cheaper and faster than the hard disks coming through the serial port. If you have no interest in hard disks, there are cheaper ways to get a megabyte of RAM than the new main logic board.

Get the new keyboard only if you enter lots of numeric data.

CONCLUSIONS

The Macintosh Plus solves most of the problems of the original 128K-byte Macintosh. It almost eliminates the tedious disk swapping that infuriated so many users, and the disk drives are much faster. The machine has enough disk storage and RAM space to make it possible to effectively utilize the many powerful features of the Macintosh without agonizing delays. It makes hard disk systems fast, cheap, and truly practical on the Macintosh. It does all this while maintaining good compatibility with the old system at almost the same price that the original system cost when it was initially released. The only outstanding problem is the lack of slots for expandability; it remains to be seen whether the SCSI port truly solves that problem.

Here at last is a machine with the much-heralded Macintosh ease of use, yet with enough raw power to silence all the nagging complaints about poor performance. ■





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THREE 24-PIN DOT-MATRIX PRINTERS

BY ROBERT D. SWEARENGIN

A look at three quality printers with various features and prices

Printer shoppers look for the best combination of speed, versatility, output quality, and price. The 24-pin dot-matrix printers generally get high marks in the first three categories, but there is a wide range in functionality and price.

At $1845, the state-of-the-art Nissho NP-2410 is not for low-budget operations. On the other end of the price range, the $699 Toshiba P321 has fewer frills and is affordable for small businesses and some home applications. Between these two is the Fujitsu DL2400 for $1195, with a color model available for $1395. All three printers performed well during six weeks of testing.



Surprisingly, print quality was not a significant variable. Such judgments are always somewhat subjective, but output from the Toshiba P321 certainly compares favorably to that from the more expensive machines. In fact, I liked Toshiba's Courier 10, a font that is available in all three printers, the best. What do you get for more money? Speed, versatility, convenience, and durability, assuming it's reasonable to base the latter quality on size, weight, and print-head life.

FEATURES AND OPERATION

The Nissho NP-2410's front panel is deceptively simple, considering the number of features it has. Three LEDs indicate power on, on-line, and paper out. The first of six switches controls on-line and off-line. The Reset switch clears the 4K-byte buffer and updates printer defaults, and TOF (top of form) advances a new page to a preset top of form. The FF (formfeed) switch feeds forms according to a preset length, LF (linefeed) advances the platen one line at a time (or continuously when you hold it down), and Sheet Load advances single sheets to the proper starting position.

The printer gets interesting when you discover the flip-open door just to the left of the main controls. A concealed panel offers a variety of options including seven fonts residing on two chips inside the printer. With a thumbwheel you select draft quality in 10, 12, 15, or 18 pitch or letter quality in Courier 10, Letter Gothic 12, or Century, which has proportional spacing. You can also dial an optional plug-in dual-font cartridge or download a font from disk.

Once you've selected a font, more options await you. One slide switch changes print style from standard (roman) to italic; another gives emphasized print. Two additional switches let you select bidirectional or unidirectional printing and six or eight lines per inch. A thumbwheel lets you select ten form lengths ranging from 3 to 14 inches.

Finally, eight DIP switches behind a back interface panel provide more choices. The first four set on-line, skip perforation, automatic linefeed, and IBM or Epson LQ-1500 graphics. The remaining four switches let you select international character sets for eleven countries.

The Fujitsu DL2400 offers comparable features on its front panel that are also deceptively simple but not as easy to operate. The selection process requires a little more time and manipulation. An LED indicates power on. For other information, you cycle through the options on a 16-column LCD choosing different combinations from only four buttons that have three functions each. The standard functions are printed on the buttons them-

(continued)

Robert D. Swearengin (Department of Journalism and Printing, P.O. Box 1930, Arkansas State University, State University, AR 72467) is an instructor of journalism and a freelance writer.

selves: On-Line, FF, LF, and Reset. Pressing Reset in the on-line mode clears the 8K-byte buffer and initializes the printer.

When you hold it down, Reset becomes an Alt button and changes the button functions to the commands that are printed underneath them on the front panel. LF becomes Micro LF, which advances the paper only 1/180 inch for fine adjustments. FF becomes Load and sets new paper to the correct starting point for printing. On-line changes to Setup and activates a third set of commands printed directly over the buttons. On this Setup line, FF changes to Function and takes you through the main menu on the LCD: style setting, interface setting, save mode, setup listing, self-test, hex dump, and default setting. LF now changes to Item and lists a submenu for each function. The Reset button changes to Select and lets you pick options from the submenu. The On-Line button, labeled Exit in the Setup mode, simply puts the printer back on-line when you've finished setting parameters.

This process is confusing at first. My initial reaction was that too few buttons control too many functions, although after about an hour of practice I was changing setups with little difficulty.

Let's say you want to change from the default, Courier 10, to Draft 12. You first press On-Line (Setup) while holding down Reset (Alt); the LCD display changes from ON-LINE:READY to SETUP MODE, and then to FUNCTN:STYLE, which is the first display in the setup mode. Because this is the function you need, you don't have to press FF (Function) to go through the menu. You simply press LF (Item) until the display reads QUALITY:DRAFT, and press Reset (Select) to lock it in. Then you repeat the last two steps to select CHAR SP:12 CPI, press On-Line (Exit), and you're ready to print Draft 12.

If you want Draft 12 to be the new default setting, you can put it in the printer's nonvolatile EPROM using the save mode. In addition to Courier and Draft, you can also choose Prestige Elite or an attractive Compression 18 font.

Using the same process, you can change just about everything else from the front panel, including character sets, ten languages, print attributes (italic, bold, etc.), color, line spacing, page length, margins, interface specifications, and IBM/Epson graphics emulation.

The Toshiba P321 has a straightforward control panel with no frills or programming options, and it is therefore the easiest to operate for routine printing. [*Editor's note: A model that has both parallel and serial interfaces is available for* $749.] However, you must rely on control codes and DIP switches to access most of its features. Four LEDs indicate power on, alarm, paper end, and select (on-line). Three switches for paper feed, top of page, and select/deselect complete the panel.

DIP switches 2 and 3, easily accessible inside the top cover, set type fonts, pitch, and several other printing options. You can select Draft, Courier, Prestige Elite, or an optional dual-font plug-in cartridge and set pitch at 10, 12, 16.7, or proportional spacing. Other switches control form length, a 256K-byte buffer, and the standard commands for carriage return, line feed, bidirectional printing, etc.

You can also choose character sets for IBM and seven languages. DIP switch 1 (available on the parallel and serial model) comes with a dual port and sets the interface, data bits, protocol, data rate, and parity.

Like the more expensive printers, the Toshiba P321 produces emphasized, expanded, italic, underlined, and bit-imaged graphics with control and characters codes. An optional kit for downloading fonts from disk is available for $89; IBM graphics printer emulation is $49. The basic printer comes with Toshiba escape sequences and Qume Sprint 11 daisywheel emulation.

Speed and Quality

Draft 10 and Courier 10 provide a reasonable comparison of speed and quality since all three printers share these fonts. Factory specifications are noted in parentheses next to the throughput measured with the BYTE benchmark test, 50 lines of 60 *A*s at 6 lines per inch.

The Nissho NP-2410 printed Draft at 188 (300) characters per second and Courier at 108 (150) cps. The Fujitsu DL2400 printed Draft at 109 (180) cps and Courier at 49 (60) cps, and the Toshiba P321 printed Draft at 92 (180) cps and Courier at 41 (60) cps. Speed is not as critical with italic type because it's generally used in short measures, but I ran a test with Courier 10 italic out of curiosity. The Toshiba and Fujitsu printers ran at about the same speed, losing only 1 to 4 cps. However, the Nissho paused at the end of each line and slowed drastically to 25 cps—something to consider if you frequently print large blocks of italic type.

All three printers performed well on 10-page sliding-character tests, with no noticeable change in impression or alignment. All three produced quality output, as the type samples indicate. However, the letter-quality designation for Courier 10 on the Nissho NP-2410 is questionable. The type is not as dense as the Courier from the other printers, and a near-letter-quality rating might be more appropriate. In fairness, the Nissho prints letter-quality emphasized Courier 10 at 73 cps, which is considerably faster than the other two printers. It also does letter-quality Century, a denser face not resident in the others, at 100 cps. (See page 257 for a side-by-side comparison of features and prices.)

Complaints

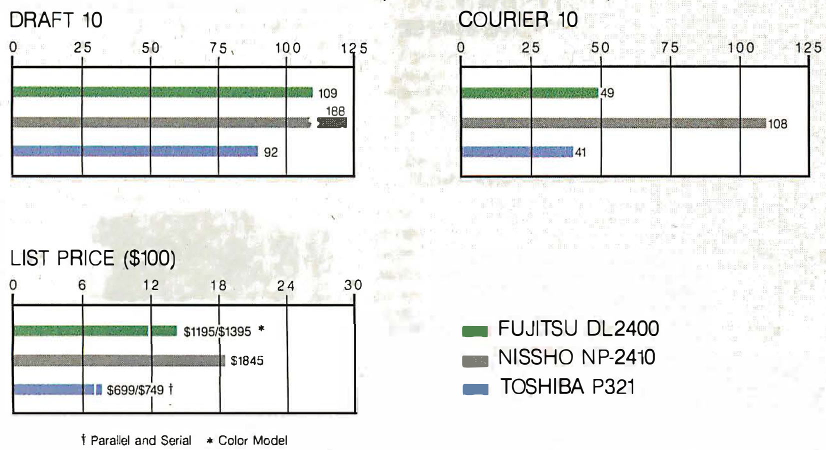
The access cover on the Nissho NP-2410 is not hinged; instead, it attaches with two flexible straps and flops back in an ungainly fashion when opened. The result is too much play from side to side; you must align it carefully to snap it back in place and put the printer on-line. The paper guide is flimsy and the two sections tend to fall apart during installation, although it worked fine once it was attached.

Front-panel programming on the Fujitsu DL2400 is a bit complex; if you're a casual user or don't change modes often, you'll probably have to check the manual to refresh your memory. Furthermore, this manual is the

(continued)

	Fujitsu DL2400	**Nissho NP-2410**	**Toshiba P321**
Type	24-pin dot-matrix printer	24-pin dot-matrix printer	24-pin dot-matrix printer
Company	Fujitsu America Inc. Storage and Peripheral Products Division 3055 Orchard Dr. San Jose, CA 95134 (408) 946-8777	Nissho Information Systems 10855 Business Center Dr. Cypress, CA 90630 (714) 952-8700	Toshiba America Inc. Information Systems Division 2441 Michelle Dr. Tustin, CA 92680 (714) 730-5000
Size	7½ by 22½ by 15½ inches 44 pounds	6 by 23½ by 17 inches 41 pounds	6 by 16½ by 13 inches 20 pounds
Features	Wide carriage, tractor feed, 8K-byte buffer, IBM/Epson FX-80 graphics emulation, dual interfaces	Wide carriage, friction feed, 4K-byte buffer, IBM/Epson LQ-1500 graphics emulation	Standard carriage, friction feed, 256K-byte buffer; Qume Sprint 11 daisy-wheel emulation, parallel interface port
Graphics resolution:	180 by 360	180 by 360	180 by 360
Resident faces:	Draft, Courier, Prestige Elite, Compression	Draft, Courier, Letter Gothic, Century	Draft, Courier, Prestige Elite
Print-head life:	300 million characters	200 million characters	100 million characters
Ribbon:	Black: $30; 15 million impressions Four-color: $39.50; 3.6 million impressions	$15; 15 million impressions	$12; 1.6 million impressions
Options	Single-font cartridge: $45 Single-bin sheet feeder: $495 Dual-bin sheet feeder: $695 Dual-bin sheet feeder plus envelopes: $900	Dual-font cartridge: $60 Serial port: $100 48K-byte buffer: $250 Bidirectional tractor feed: $195 Single-bin sheet feeder: $295 Dual-bin sheet feeder: $595	Dual-font cartridge: $69 Downloadable font kit: $89 IBM graphics emulation: $49 Tractor feed: $99 Single-bin sheet feeder: $219
Documentation	170-page user's manual; optional programmer's manual: $15	80-page user's guide; 100-page technical manual	154-page user's manual
Price	Basic model: $1195 Color model: $1395	$1845	Parallel-only model: $699 Parallel and serial model: $749





Benchmark comparisons of the Nissho NP-2410, the Fujitsu DL2400, and the Toshiba P321 using 10-pitch Draft and 10-pitch Courier fonts. For each font, print speeds were determined by timing in seconds how long it took to print 50 lines of 60 As. For more information on benchmark tests, see "The Art of Benchmarking Printers" by Sergio Mello-Grand, February 1984 BYTE.

weakest of the three: the programming information needs more detail, particularly the section on graphics. An optional programmer's manual costs $15.

The Toshiba P321 advances the ribbon with a length of cord that stretches across the inside of the printer and wraps around a wheel underneath the carriage. For me, this was a trap. The manual's setup instructions say to remove the white "plastic tie wrap" to free the carriage for printing. Mine had no such wrap, and I assumed the company had switched to a cord, which I dutifully removed. The ribbon didn't advance when I started the printer, and I spent half an hour figuring out what was wrong and reinstalling the cord. After that, it worked fine. I was nervous about this low-technology hookup, which reminded me of the dial cords on old radios, but I experienced no problems during operation.

PICK A PRINTER

Complaints aside, all three printers performed as advertised and eliminated most of my reservations about dot-matrix machines in general. The Nissho NP-2410 control panel beats any I've seen for features and ease of use. With its speedy output, wide carriage, and hefty proportions (6 by 23½ by 17 inches and 41 pounds), it should nicely handle high-volume processing. The print-head life is rated at 200 million characters. However, with a tractor feed and other options such as a serial port, you'll pay over $2000.

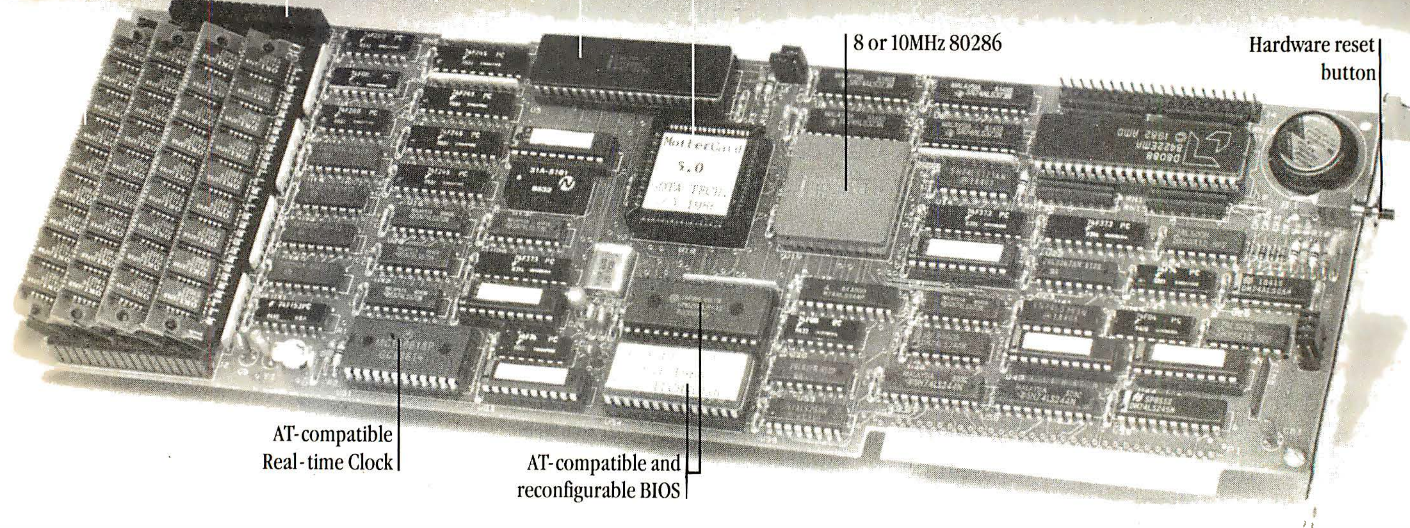
With the Fujitsu DL2400 you'll sacrifice some speed, operating ease, and convenience for a much lower price tag, but it's also a wide-carriage, hefty machine (7½ by 22½ by 15½ inches and 44 pounds) with a print-head life of 300 million characters. Dual interfaces and a tractor feed are included in the $1195 base price, an important consideration if you're watching your budget. The color model, which is $200 extra, is also attractive: It prints black, yellow, magenta, cyan, violet, orange, and green from a four-color ribbon.

The Toshiba P321, with a print-head life of 100 million characters, weighs 20 pounds with its standard carriage and small footprint (6 by 16½ by 13 inches). Aside from the cord on the ribbon advance, it seems to be sturdily built. It has no special features, and you'll pay extra for tractor feed and such niceties as IBM emulation, the downloadable font kit, and the parallel and serial interface model. Nevertheless, in output quality and overall printing capability, it held its own against the more expensive printers. This one is a contender for small- to medium-volume users.

If you need reasonable speed, quality, and flexibility but don't want to pay for a laser printer, consider one of these printers as a viable alternative. Let the trade-offs between functionality, reliability, and price be your guide. You must make the final choice by assessing the costs and benefits for your particular application. ■

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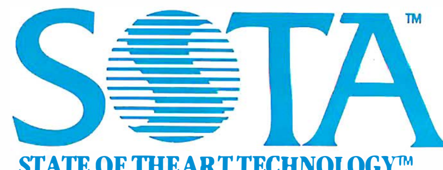
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DIGITIZERS FOR DATA ENTRY

BY ELDON D. HEARN

A survey of eight devices for entering graphics data into personal computers

A digitizer is an electronic tablet used to enter the coordinates of specific points of graphic information into a computer. You point at the location on a map or drawing with a stylus or cursor and the coordinate data is automatically sent to your computer. Once installed, it's simple to use and usually accurate to within a few hundredths of an inch.

Table 1 lists the eight digitizers I have compared, with a compilation of each machine's attributes. The list contains 80 percent of the digitizer manufacturers in the U.S. My company's development laboratory has used at least one model of each digitizer.

PRICE

Several prices are listed in table 1 if a digitizer is available in more than one size. These prices include no options, although options can add substantially to the overall price of the digitizer. All sizes represent the active area of the digitizer. All manufacturers buffer the active area by various distances, so the overall size of the digitizer is somewhat larger. One model, the Microgrid series, is contained in a drafting table and is quite large. It can be turned vertically and used in that fashion.

RS-232C SERIAL PORTS

Some digitizers have more than one RS-232C port, some have parallel ports, and some have both. You will require the parallel port option if you need faster coordinate transmission. The Intelligent Digitizer (ID) series, the Microgrid series, and the Digi-Pad 5 series have their RS-232C serial ports configured as DCE (data communications equipment) or DTE (data terminal equipment). The ID series also has one 26-pin and one 50-pin printed circuit card connector for other applications.

SPECIAL CABLES

Every manufacturer will provide a cable that matches the digitizer to your computer for an extra cost. Some digitizers will operate without a specially prepared cable. A standard serial cable will provide all the necessary connections for the Microgrid series and the Numonics 2200/2400 series. The other digitizers require some variations in the cable wiring to attach to a computer.

The RS-232C standard has been followed by all manufacturers except Houston Instrument. Although its HIPAD digitizer is nonstandard, Houston Instrument will supply you with a cable, depending on your application, to make all the necessary connections between your digitizer and computer.

Program control of serial port pin 20 (DTR) in your program is essential. If pin 20 of the serial port is enabled, the computer will accept serial transfer with a digitizer that follows the RS-232C standard. Most communications programs do this. PC-Talk and Crosstalk will communicate with your digitizer if you set both the digitizer and the program to the same data rate, word length, parity check, and stop-bit parameters.

DATA FORMAT

All digitizers transmit their coordinates in either ASCII or packed binary code. Packed binary can represent the same data but in a different binary format. This is optional on all but one digitizer, the HIPAD, and is switch-selectable. The form differs between manufacturers, but usually the *x* coordinate precedes the *y* coordinate. In this article, the ASCII format will be assumed.

On most digitizers the coordinate format is set, but some digitizers allow certain switch-selectable options. An additional digit of *x* and *y* value may be optional, or a decimal point may be included somewhere within the formatted string. Usually, the more digits that are transmitted with each coordinate, the greater the resolution from that digitizer will be. All digitizers can send their coordinates in inches or millimeters, and that is also switch-selectable for all but the HIPAD digitizer.

Included somewhere in the coordinate format and transmitted from the digitizer is a one- or two-character code that represents the key you pressed at the digitizer cursor when you digitized that particular point. The location of the character generally is the first or last character transmitted. Even if you have a one-button cursor or a stylus, the character or characters are transmitted with each coordinate pair. On the ID series of digitizers, a tablet identifier is the first character transmitted, and it gives you the option of utilizing more than one tablet with your computer.

On some digitizers, particularly the ones that allow a relocatable origin, a plus sign or a minus sign precedes

(continued)

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the x and y coordinates. Some digitizers will transmit only a minus sign when the coordinate is negative, with an unsigned coordinate considered positive.

The coordinate format is controlled by a ROM or PROM chip within the digitizer. Some manufacturers can emulate their competitors' digitizers by replacing this chip with another that transmits the proper coordinate format. If you have a program that works with another digitizer but not yours, check with the manufacturer. They might have a replacement ROM that emulates that digitizer, and you might be able to use the program.

BINARY FORMAT

The binary format allows faster communication from the digitizer and is often used in conjunction with a parallel port. The transmission from the digitizer is in binary notation and requires fewer bytes to transfer a coordinate than an ASCII coordinate. However, its use complicates the interfacing of both digitizer and computer. Most digitizers have the capacity to overwhelm a good program with the ASCII format; thus, it seems unnecessary to complicate your interface with this option.

BIDIRECTIONAL COMMUNICATION

Most digitizers can transfer their coordinates via the RS-232C connection at 150 to 9600 bits per second. Usually the rate is set by toggling certain switches, but one of the digitizers, the Summagraphics MM1201, will automatically sense the data rate of your computer.

Feedback to the digitizer is called bidirectional communication, and the function of automatically sensing the data rate is called autobaud by Summagraphics.

RESET SWITCH

The Numonics 2200/2400 series of digitizers and the HIPAD have a reset switch, a handy refinement. Without a reset switch, you must turn the digitizer off and then back on again to enable changes whenever the digitizer switches are changed. The ID series has a "clear" switch at the controller to perform any switch change during power-up.

TEST DISPLAY

Some digitizers have a test display that will let you observe the coordinates sent by the digitizer to the computer. You can purchase an optional test display if your program doesn't write the digitizer coordinates to the monitor in either numerical or graphic form and you need to see the coordinates of the point you digitized.

COMMAND INPUT BUFFER

Some newer digitizers with bidirectional communication have a buffer that will accept commands you transmit to the digitizer. The Bit Pad Two and the MM series of digitizers have a 10-character buffer size. The Microgrid series has a 64-character buffer.

The Numonics 2200/2400 series, the Digi-Pad 5 series, and the GP-7 and GP-8 have an unknown buffer size. You can build a file within the buffer limit that contains the commands to preset the digitizer to your application. You can then transmit the file to the digitizer with a communications program such as PC-Talk or Crosstalk.

SWITCH-SELECT FUNCTIONS

There are only three digitizers that do not have the usual number of switches to preset for functions or modes. These are the MM series, in which jumpers are used, and the GP-7 and GP-8, in which some functions and modes can be picked from a command menu defined just above the active area of the digitizer. The only other switches that require setting on the GP-7 and GP-8 are the communication switches located in the controller box.

POWER SUPPLY

All the digitizers discussed in this review require 110-volt AC electrical power. The ID series' power supply is in its controller and is separate from the digitizer. All the other digitizers have a wall-mounted transformer that is part of the power plug. Only the Digi-Pad 5 series has an on/off switch on its power supply. The other digitizers require you to remove the power supply from the outlet to power down. If you purchase one of the digitizers without an on/off switch, you may want to use an extension cord with an attached toggle to turn off your digitizer.

STYLUS/CURSOR

The Stylus/cursor category in table 1 has two entries for each digitizer. The first entry shows the number of stylus buttons with which the digitizer can be equipped. The second entry shows the number of cursor buttons available on the digitizer's cursor. An "S" indicates a stylus without any buttons. In the case of the Digi-Pad 5 series, "5" in the first entry indicates that a 5-button stylus is available. A 5-button cursor is indicated as "5" in the second entry.

Each of the digitizers listed in table 1 comes with either a stylus or a cursor as an option. These devices direct the point or points that the digitizer will transfer to the computer. When the stylus or cursor is close to the digitizer surface and you press the stylus or a cursor button, the digitizer will transfer to the computer the coordinates of the point under the stylus or the point located at the junction of the cross hairs on the cursor. If you need just the point's coordinates, a stylus is adequate. But if you need point identification along with the coordinates, you may want to choose a cursor with enough buttons to identify each category of each point you transfer. The Digi-Pad 5 series of digitizers provides a 1-, 5-, and 16-button stylus as well as a 1-, 5-, and 16-button cursor. With the multibutton cursor you can define a certain key to call your program or terminate your digitizing sequence. With a two-button stylus, you can use the switch on the outside of the barrel as a terminating switch.

MODES

All digitizers have three modes: point, switch stream, and stream. These modes are the same for all machines, although there are other modes such as incremental and remote. Point transfer by the digitizer is a function of its data rate. A digitizer set at 9600

(continued)

Table 1: *Comparison of features for the eight digitizers. Included are the important features and options for the most commonly available models.*

Name	Intelligent Digitizer (ID) series	Bit Pad Two	Microgrid series	MM series	2200/2400 series	HIPAD	Digi-Pad 5 series	GP-7, GP-8
Company	Summagraphics Corp. 777 State St. Extension Fairfield, CT 06430 (203) 384-1344	Summagraphics Corp. 777 State St. Extension Fairfield, CT 06430 (203) 384-1344	Summagraphics Corp. 777 State St. Extension Fairfield, CT 06430 (203) 384-1344	Summagraphics Corp. 777 State St. Extension Fairfield, CT 06430 (203) 384-1344	Numonics Corp. 418 Pierce St. Lansdale, PA 19446 (215) 362-2766	Houston Instrument Corp. 8500 Cameron Rd. Austin, TX 78753 (800) 531-5205	GTCO Corp. 1055 First St. Rockville, MD 20850 (301) 279-9550	Science Accessories Corp. 970 Kings Highway W Southport, CT 06490 (203) 255-1526
Price	$2500 $6000	$499 (Both models)	$2375 to $5085	$291; $445; $895	$859 to $6595	$840	$1045 $6750	$995 $3175
Size (inches)	11 by 11 42 by 60	11 by 11 (Both models)	17 by 24 to 42 by 60	6 by 9, 11½ by 11½, 18 by 12	12 by 12 44 by 60	11 by 11	11 by 11 to 42 by 60	18 by 24 60 by 72
RS-232C serial ports	2	1	2	1	1	1	2	2
Special RS-232C cable	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Parallel port	2	No	Optional	Optional	No	Optional	Yes	Optional
ASCII format	SS	SS	SS	SS	SS	Yes	SS	Yes
Binary format	SS	SS	SS	SS	SS	Yes	SS	Optional
Bidirectional communication	No	Yes	Yes	Yes	Yes	No	Yes	Optional
Reset switch	Yes	No	Yes	Yes (MM1812 only)	Yes	Yes	No	From menu
Test display	Yes	No	Yes	No	No	Yes	Yes	No
Command-input buffer	N/A	10 characters	64 characters	10 characters	Unknown	N/A	Unknown	Unknown
Switch-select functions	Yes	Yes	Yes	Jumpers Switches (MM1812)	Yes	Cable-selected	Yes	From menu
Power supply	In controller	Wall-mounted	Wall-mounted	Wall-mounted	Wall-mounted	Wall-mounted	Wall-mounted	Wall-mounted
Stylus/cursor	S 1, 4, 13	S 3, 4	1 3, 4, 16	1 3, 4	S 1, 4, 16	S 1, 4	1, 5, 16 1, 5, 16	S 1, 4
Modes	PT, SWST, ST	PT, SWST, ST	PT, SWST, ST	PT, SWST, ST	PT, SWST, ST	PT, SWST, ST	PT, SWST, ST	PT, SWST, ST
Coordinate alteration	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Self-test	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
On/off switch	Yes	No	Yes	No	No	No	Yes	Yes
Origin	F & R	F (model 1103) R (model 1105)	F & R	F & R	F & R	F & R	F & R	F & R
Resolution (lines per inch)	100 to 200	100 to 508 (rel.mode) 400 to 508 (abs.mode)	200 to 1016	100 to 1000	1 to 1000	100 to 1000	SS 1 to 1000	100
Accuracy (inches)	.004	.025 .005	.010 .005	.025 to .005	.01 to .005	.01 to .005	.010 to .003	.01 to .005
Sampling rate (counts per second)	Potentiometer 1 to 100	SS 2 to 154	SS 2 to 200	SS 2 to 200	SS 8 to 200	SS 1 to 100	SS 1 to 200	SS 25 to 200
Weight (pounds)	11 105	7	(Installed in drawing table)	8	4.5 30	5	8 to 100	8 (GP-7); 12 (GP-8)
Special features	Configured serial ports DCE, DTE	Two modes of operation	Vertical use; numerous options	Autobaud; two modes of operation	Large menu area; easy access to switches	Easy mode setting	High accuracy	Low price; large area

The resolution of a digitizer is the smallest distance it can distinguish.

bps will stream more coordinate pairs than one that is set at 300 bps. (The word *stream* is used in the sense that one coordinate pair follows another until you terminate the transmission.) Point mode will transmit one coordinate pair to the computer for each press of the stylus or cursor button. Switch stream mode will stream the coordinate pairs to the computer only when you press and hold down the stylus or cursor button. Stream mode will stream the coordinate pairs until you power-down the digitizer. In the Modes category in table 1, point mode is abbreviated as PT, switched stream mode is SWST, and stream mode is ST.

The ID series of digitizers' controller has buttons that let you easily access these three modes. The Bit Pad Two, Microgrid series, MM series, 2200/2400 series, and the Digi-Pad 5 series let you set these modes by either physically changing the internal switches or transmitting a certain code to the digitizer. The HIPAD lets you set three modes from buttons located on the front of the digitizer. The GP-7 and GP-8 digitizers have a menu in front of their controllers from which you can choose two modes or reset to the default setting. The easiest settings are, of course, the settings made from the computer, but they are transitory and revert to the original switch settings when you turn off the digitizer.

COORDINATE ALTERATION

Coordinate alteration lets you change the coordinate format of the digitizer without changing the ROM chip. Alteration will operate on the ASCII or binary coordinate format whether the coordinates are in U.S. customary system or metric units. If no alteration is available for a particular digitizer, then "No" is indicated in the table. If alteration is available, "Yes" is used. The ID series of digitizers has DIP switches that can select many differing coordinate formats such as adding another digit in x and y coordinates or including a decimal point at specific locations.

The Bit Pad Two machine has only two types of alteration: absolute mode and relative mode. If you set a certain switch, the digitizer will alter its coordinate format to include a plus or minus sign in the format. This is called relative mode. In relative mode the digitizer will report its coordinates relative to the preceding point that was digitized. In absolute mode, an origin is fixed at the lower left corner of the digitizer, and the coordinate format is changed accordingly. The relative mode is not available in binary format.

The Microgrid series is somewhat different in its alteration scheme. Both U.S. customary system and metric-unit formats are available in either high or low resolution. You can specify the format to include a decimal or a delimiter (a comma or any ASCII character) and to terminate the coordinate with either a carriage return or a carriage return and linefeed.

The MM series of digitizers' coordinate formats are dependent on the resolution setting on the tablet and whether you have set the tablet in delta mode. For the MM1201 digitizer, for instance, if you set the resolution between 1 and 508 lines per inch, the digitizer will output a coordinate pair that has one less significant digit than if you had set the digitizer's resolution above 1000 lpi. The MM961 digitizer outputs its coordinates just like the MM1201 but does so for resolutions from 1 to 1016 lpi. It too can be set in delta mode.

You can change the Numonics 2200/2400 series of digitizers' coordinate format only by sending host commands to the digitizer. By specifying certain commands, you can drop either the first or the last digit of the coordinate pair. You cannot enable the format by a switch.

The HIPAD digitizer's coordinate format is preset and cannot be changed or enabled by setting a switch. The Digi-Pad 5 series' coordinate format can be changed only in the packed binary format of high and low resolution.

The GP-7 and GP-8 sonic digitizers' coordinate formats are also preset and cannot be changed by setting a switch. In stream mode the coordinate format will change to include a flag to indicate whether the stylus or cursor is near the digitizer surface.

SELF-TEST

Every digitizer except the GP-7 and GP-8 has a self-test function to test the digitizer's circuitry. The Numonics 2200/2400 series can also check the main PROM chip and identify its number and output. You usually invoke the self-test check by setting a switch or by transmitting a certain code to the digitizer.

ON/OFF SWITCH

The only digitizers that have a convenient on/off switch are the GP-7 and GP-8, the Microgrid series, the Digi-Pad 5 series, and the ID series. The switch on the latter is convenient only if you have placed the controller close by. The other manufacturers seem to want you to leave the machine turned on, for they have made no provision to power-down the digitizer other than by removing the power source from the wall outlet.

ORIGIN

You can get the Numonics 2200/2400 series and the Bit Pad Two digitizers with a fixed origin. The origin is permanently placed at the lower left corner of the digitizer, and the letter F is used in table 1 to designate a fixed origin. The letter R is used where the origin is relocatable. The MM series of digitizers has a relocatable origin, but the origin can be placed only at the upper or lower left corner of the digitizer. The Microgrid series of digitizers' origin defaults to the lower left but can be relocated anywhere within the active area. In cases where the digitizer defaults to some origin that can be relocated somewhere else on the digitizer by setting a switch, the abbreviation F & R is used.

RESOLUTION

The resolution of a digitizer is the smallest distance or movement that

the digitizer can distinguish. This distance is measured in lines per inch, and you usually can set it at particular switches within the digitizer. The greater the numerical resolution of a digitizer, the smaller the movement that can be detected and reported to the computer.

One digitizer, the Bit Pad Two, is configured so that its resolution differs when in absolute or relative mode. Most digitizers' resolutions vary from 1 to just over 1000 lines per inch. Digitizers with the highest resolution report their coordinate pairs in five significant figures. For a given digitizer of 60 by 72 inches, the coordinates would be reported as 60000, 72000 (inch units and ASCII format) plus or minus the accuracy of the digitizer. As you can see in table 1, the higher-resolution digitizers are not necessarily the most expensive ones.

ACCURACY

The Accuracy category in table 1 lists the claimed accuracy for each digitizer. The accuracy of a digitizer is measured by how closely a point is reported as compared to its actual location on the grid.

SAMPLING RATE

On most digitizers you can set the sampling rate, or report rate, by a switch or a combination of switches on the digitizer or by transmitting certain codes to the digitizer from the computer. Rates of coordinate transmission depend on the digitizer's data rate. Usually data rates above the digitizer's capacity to transmit are ignored. You will attain the ability to transmit a maximum of 200 coordinate pairs per second only at data rates of 9600 bps and higher. The Numonics 2200/2400 series' sampling rate can be set to delay the transmission of each coordinate pair for as long as eight seconds in stream mode. The sampling rate of the ID series can be set by means of a potentiometer, or slide switch, located on the controller.

SPECIAL FEATURES

Each digitizer has certain special features that make it unique. The ID series of digitizers will transmit coordinate pairs with high accuracy. It is easy to use, with all mode switches on the front of the controller and the on/off switch on the back. You should have an application program available for the digitizer before buying it because the serial interface is somewhat intimidating. The programmer will appreciate the ID series. One RS-232C port is configured as DCE and the other as DTE.

The Bit Pad Two is available in two models: the 1103, a low-accuracy model, and the 1105, a high-accuracy model. The two models are available in only one size, 11 by 11 inches. Both models have bidirectional communication. There is neither an on/off switch nor a reset switch. The sampling rate is switch-selectable. The sheer number of DIP switches can be overpowering at times, but an experienced programmer can work with more than one application without resetting a single switch.

The Microgrid series of high-accuracy digitizers are mounted in drafting tables. Sizes range from 12 by 12 inches to 42 by 60 inches. The series has bidirectional communication and switch-selectable sampling rate. The tablet also contains two RS-232C ports, one configured DTE and the other DCE. The table has a tilt top and can be used in the vertical position. Its origin is relocatable, and the tablet has a convenient on/off switch. All users will find the Microgrid series easy to operate. A standard serial cable will configure the tablet to an RS-232C serial port on the computer.

The MM series of digitizers is both a high- and low-accuracy series. Sizes range from 6 by 9 inches (MM691) to 11½ by 11½ inches (MM1201) and 18 by 12 inches (MM1812). The MM691 and the MM1201 have the autobaud function. The data rates of the MM1812 can be switch-selectable or selected by autobaud. The MM691 and MM1201 have a delta mode to provide coordinates relative to the last coordinate issued. This mode is called the relative-position mode on the MM1812. The MM1812 also provides a coordinate format called UIOF (universal input/output format), which is the beginning of format standardization across the entire Summagraphics product line.

Accuracy is measured by how closely a point is reported compared to its actual location on the grid.

The MM691 and MM1201 are somewhat difficult to initially interface to a computer, but the MM1812 is more convenient.

The Numonics 2200/2400 series of digitizers can define a separate menu area of the digitizer, from which you can pick predefined symbols or functions. The number of columns and rows and cell width and height can be set anywhere within the active area of the digitizer. None of the other digitizers has this feature.

The Numonics 2200/2400 series also provides easy access to the DIP switches located inside the digitizers' cases. Simple slots provide open access to the switches without requiring you to remove the back of the digitizer. This is also true with some other digitizers.

Some of the HIPAD digitizer's mode switches are placed conveniently on the digitizer, giving you ready access to point mode, switch stream mode, and stream mode. A reset switch is also in this group of switches. You must remove the digitizer's power source from the wall outlet to power-down the unit.

The HIPAD is the only digitizer that has a nonstandard RS-232C communications port. Certain options must first be grounded to a particular pin before being enabled or disabled. The HIPAD transmits its coordinates with high accuracy in ASCII coordinates or in binary format. The HIPAD does not support bidirectional communication, but the tablet has a relocatable origin.

Initially the HIPAD may be difficult to interface, but the company support

(continued)

is excellent. However, an experienced user may be disappointed by the lack of options. Houston Instrument's upcoming True Grid series of digitizers should rectify all the inadequacies of the HIPAD.

The Digi-Pad 5 contains a Z80A microprocessor. The company claims the digitizer also has a higher degree of sophistication due to its patented electromagnetic principle. The Digi-Pad 5 offers about the same options as the ID series, but with the added capability of bidirectional communication.

GTCO Corporation supports almost every coordinate format available in a digitizer. It supplies PROM chips that can emulate its competitors' formats. The stylus of the Digi-Pad 5 digitizer is unique. Certain configurations of a 1-, 5-, and 16-button stylus are available, including a Tilt option that lets you determine the tilt of the stylus with respect to the surface of the digitizer and ultimately the direction in which the stylus is angled. Thus, the stylus functions as an effective joystick. A pressure-sensitive stylus is also available.

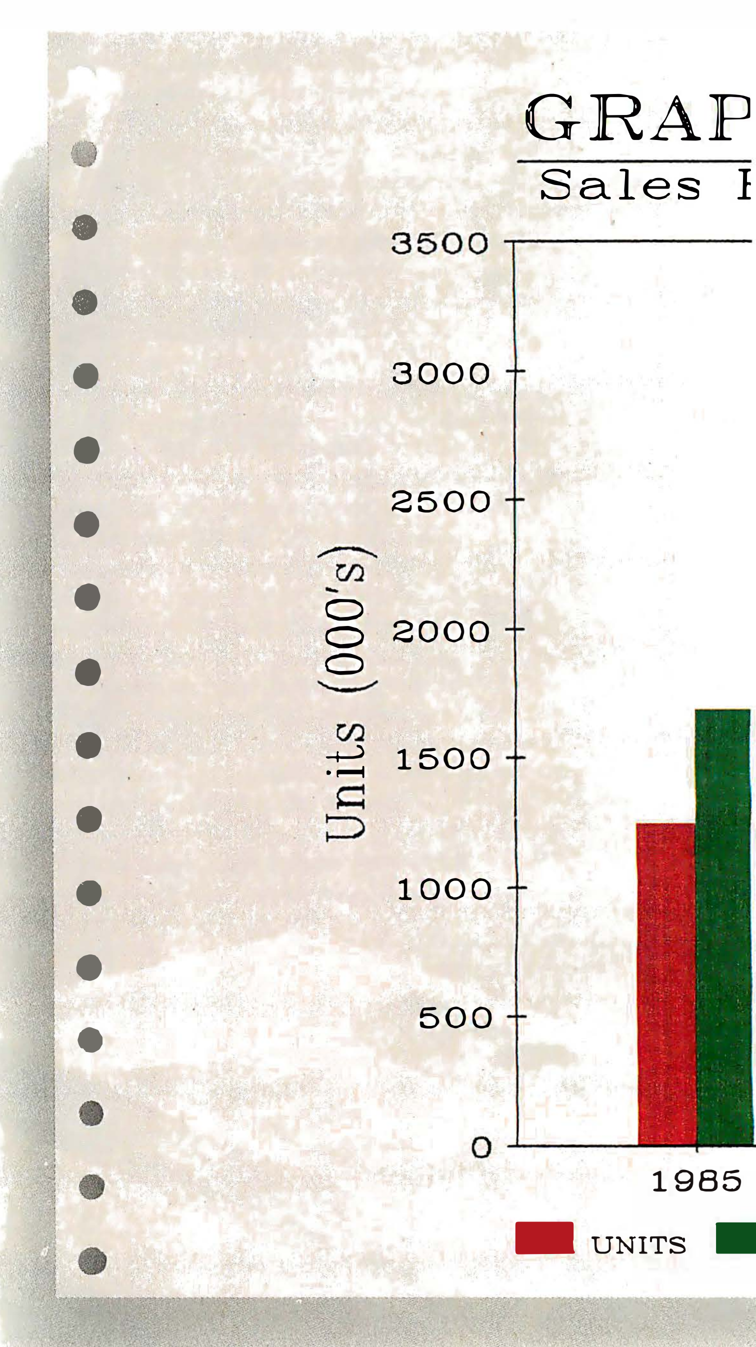
The only digitizers that are exceptionally different from all the others are the GP-7 and the GP-8. They operate on a sonic principle with a sound transmitter located in the stylus and two receivers located some distance apart on the controller. To digitize a point you merely depress the stylus, which transmits a sound. The sound is picked up by the receivers on the controller, and the differences in the x and y coordinates are calculated. Adjacent to the controller is a menu area from which you can pick certain functions or modes with the stylus. The GP-7 and GP-8 are easy to set up and use.

CONCLUSION

Digitizers are the most effective method of transferring coordinate data from a map or diagram to a computer. Each of these digitizers offers some function or combination of options that makes it unique. Careful selection of the functions that best suit your applications is the only way to assure yourself satisfactory operation of your system. ■

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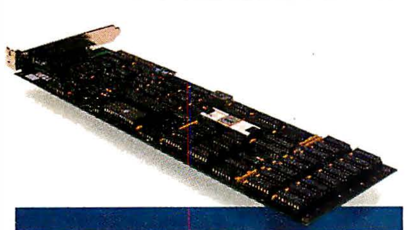
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NEC	µPD70108/116 (V20/30)	DIP40P	○	
	µPD70208/216 (V40/50)	PGA	○	
MOTOROLA	MC68000	DIP64P,PGA68P		○
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	Z8 (Z8601/03/11/13-12R)	DIP40P	○	
	SUPER-8 (Z8310-33)	DIP40/48P	○	
INTEL	80C85, 8085AH-2	DIP40P	○	
	8048 (8035/39/40/49/50AH)	DIP40P	○	
	8051 (8031/51AH, 80C51)	DIP40P	○	
MOTOROLA	MC6801 (6801/03-1)	DIP40P	○	
	MC6809 (68A09, 68809)	DIP40P	○	
	MC6809E (68A09E, 68B09E)	DIP40P	○	
	MC68HC11	DIP48P	○	
HITACHI	HD6301V/6303R, HD63701V	DIP40P	○	
	HD6301X/6303X, HD63701X	SDIP64P	○	
	HD6301Y/6303Y, HD63701Y	SDIP64P	○	
	HD6305U/V, HD63705V	DIP40P	○	
	HD6305X/Y	SDIP64P	○	
	HD6305Z, HD63705Z	FLAT80P	○	
	HD6309E	DIP40P	○	
	HD61810B (HSP)	DIP40P	○	
NEC	µPD7807/08/09	SDIP64P,QUIP64P	○	
	µPD7810H/11/14/16	SDIP64P,QUIP64P	○	
	µPD78C10/11	SDIP64P,QUIP64P	○	
MITSUBISHI	M50734SP	SDIP64P	○	
	M50745	SDIP64P	○	
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TWO C COMPILERS FOR THE AMIGA

BY CHARLIE HEATH

An all-points comparison of Lattice C and Manx Aztec C68K

Two good C compilers by Lattice Incorporated and Manx Software Systems are available for the Commodore Amiga. Both compilers have their strengths and weaknesses, and both are suitable for professional software development.

LATTICE C

Lattice worked in conjunction with Commodore to develop its C compiler for the earliest software developers. One of the most important issues in programming the Amiga is having access to all the system library calls and data structures that the Amiga uses to access its graphics and multitasking resources. Fortunately, Lattice addressed this issue from the start; the result is a complete set of binding routines and include files that define all the Amiga data structures.

MANX AZTEC C68K

The Manx Aztec C68K compiler arrived later on the Amiga scene, and its first revision was made available this spring. However, Manx Software Systems was no newcomer to the world of 68000 C compilers; it already had a C compiler available for the Macintosh. The Manx Aztec C68K compiler for the Amiga generates fast, compact code and does it quickly.

BENCHMARK RESULTS

The benchmark results heavily favor Aztec C68K. For a comparison of the compiler and linker sizes, see table 1. For the timing results, see table 2. It is important to look at the reasons why the results are as they appear. The widest gap in benchmark results occurs in two areas: floating-point math and size of object code.

In size of object code, the Aztec C68K compiler consistently produces benchmark results that are less than half the size of programs compiled under Lattice C. In the BYTE benchmark tests, the Lattice C programs average nearly three times the size of Aztec C programs. Since I have a strong interest in code optimization, I looked closely at the output of both compilers. My conclusion is that the Aztec compiler should generally produce code about 20 to 33 percent smaller than equivalent code from the Lattice compiler.

Practically speaking, the size of output code from these benchmarks is largely determined by the size of the printf library function. Manx Software Systems has done a good job of creating a very efficient printf function, but if you want to measure the efficiency of the code that the Aztec C68K compiler generates, you should factor out that difference, particularly if you do not use printf in your code. The code size for a program with the single statement "Hello, world" is 4720 bytes with Aztec C and 14,508 bytes under Lattice C. This difference has little to do with the compiler used, except perhaps as a measure of how efficient the compiler is at building the linking libraries. If Lattice Incorporated wanted to improve its C compiler's benchmarks, it could optimize the compiler's printf function.

The other major difference in size of executable files produced is due to the Aztec C68K compiler's use of 16-bit offsets for addressing data and functions. The size of int makes very little difference in the size of the executable file (although it does make a big difference in the benchmarks for speed). The difference in executable file size comes from the addressing mode used for referencing variables and functions.

The Aztec C68K compiler reserves register A4 as a base-address pointer, which is used to index a 64K-byte data region. This allows the use of 16-bit offset addressing rather than 32-bit absolute addresses. The result is code that is about 25 percent faster and 33 percent smaller for every memory reference instruction. The same method is used for function addresses: Rather than using a 32-bit absolute address, a 16-bit program counter offset is generated for function calls.

This method of addressing is the single biggest difference between Aztec C and Lattice C in the size of code generated. An overlooked fact in this assessment is that the Lattice C compiler actually supports base-relative addressing as a compiler switch. However, with the current version of ALink, it is not possible to use this feature because Metacomco, the writer of ALink, did not include support for base-relative addressing in the object code specification.

(continued)

Charlie Heath (P.O. Box 561, Cambridge, MA 02140), a cofounder of MicroSmiths Incorporated, has developed several Amiga programs including TxEd, Mean 18, and GameMaker.

Manx Aztec C68K

Type
C development package and debugger

Company
Manx Software Systems
P.O. Box 55
Shrewsbury, NJ 07701
(201) 542-2121

Necessary Hardware
Amiga 1000 with AmigaDOS; 256K bytes of RAM; one floppy disk drive

Copy-protected
No

Price
Aztec C68K Commercial version: $499
Aztec C68K Developer version: $299

Lattice C

Type
C development package and debugger

Company
Lattice Incorporated
P.O. Box 3072
Glen Ellyn, IL 60138
(312) 858-7950

Necessary Hardware
Amiga 1000 with AmigaDOS; 512K bytes of RAM; one floppy disk drive

Copy-protected
No

Price
Amiga C compiler: $149.95
Amiga IBM PC cross-compiler: $250

A couple of limitations arise when you use 16-bit offset addressing. The first is a generic limitation similar to the segmented address space of processors like the 8086; the second is an Amiga-specific issue based on the philosophy of Amiga memory management.

The first limitation is that when you use only 16 bits of address, you effectively limit the size of the addressed object to 64K bytes. This should be considered separately for code and data, since data is addressed as an offset from a base register, whereas code is referenced as an offset from the program counter. The Aztec C68K compiler and linker solves the code addressing problem by putting jump vectors into the data segment when you try to access a function that is outside the range of the current program counter. If the code is within range (32K bytes forward or backward), it is directly accessed. Otherwise, an equivalent data reference instruction is generated that jumps to a vector in the data segment. The data reference problem is more difficult to solve if you have a large data segment. The Aztec C68K compiler lets you combine modules compiled with small (program-counter-relative) and large (absolute) data segments, so it is possible to separate code into modules that reference only short-range data and modules that can reference any part of the data segment.

I am uncertain whether you can do the same with the Lattice C compiler, assuming it is possible to use its 16-bit addressing mode. This is because Lattice C uses register A5 as a base register when you use short addressing and register A5 as a register variable if you compile without the 16-bit address switch. Since the base-relative data addressing relies on a fixed-base address register, I expect there would be problems combining relative and absolute addressing with Lattice C.

The second limitation to using 16-bit offset addressing with the Amiga is the basic philosophy of the memory manager. The Amiga executive has no provisions for making available memory contiguous once it has been allocated, and the result is that often the memory map has many small regions of free memory. The Amiga's scatter-loading philosophy stipulates that the program should deal with this fragmentation by loading into a set of smaller, noncontiguous regions rather than a single large region. However, without contiguous memory you can't use addressing with a 16-bit offset; you must fall back to a 32-bit absolute address. The linker must produce code and data with many small *hunks* (i.e., blocks of code or data with relocation information) rather than a single large hunk.

This issue is a problem with the Aztec C68K compiler and linker, although Manx Software Systems has assured developers that it will address this problem in the next revision. The current revision of the Aztec C68K linker produces only a single code segment and a single data segment. This means that if your program has 180K bytes of code, it is all put into a single hunk that must be loaded into a contiguous area of memory. If there is not enough contiguous memory, the program probably will not load; if it does, it might have trouble allocating a large area of contiguous memory for the Amiga's display.

The optimum size that hunks should be is subjective. The Lattice C libraries have too many hunks: In the current release, Lattice C has many segments that only load 4 or 8 bytes of code or data. For example, the SIEVE benchmark is split into about 40 hunks. Each hunk requires about 32 bytes of disk storage and about 16 bytes at run time to identify each hunk; thus, Lattice C's benchmarks have about 1200 bytes of overhead

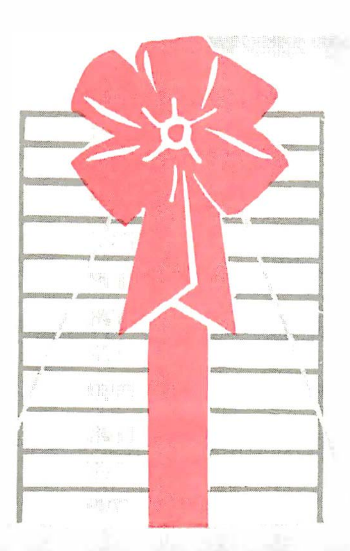
Table 1: *Sizes of files needed on disk for compiling and linking. All file sizes are in bytes.*

Aztec C68K		Lattice C	
cc	64,776	lc1	108,528
as	36,888	lc2	113,228
ln	21,296	alink	28,572
Total	122,960		250,328

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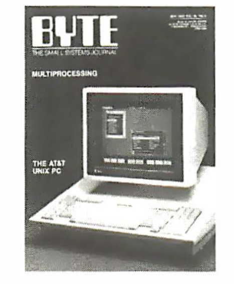


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just supporting the various hunks.

I'm looking forward to getting the Aztec C68K revision that lets you separate programs into hunks, but Aztec users beware: Your programs will get a bit fatter when you break them up into hunks.

In the floating-point math results, the Aztec C68K compiler produces results that are 10 to 20 times faster than Lattice C's. The difference, however, is simple: Lattice C uses double-precision IEEE math routines, which are very accurate but also very slow, compared with the Motorola single-precision FFP math routines that the Aztec C68K compiler uses (see the SAVAGE benchmark results in table 2). If your floating-point math requirements lean toward speed, Aztec C68K's use of the FFP routines is exactly what you need. However, if you need the IEEE precision, you'll need the Lattice C compiler.

What are the other big differences in the benchmarks? I've made little mention of speed, but the Aztec C68K compiler does very well in this area. The two compilers are about even, save for the advantages of using relative addressing, when using 32-bit integers. In fact, the Lattice C compiler does a better job of optimizing in terms of remembering intermediate results rather than recalculating them in two adjacent source-level statements. An example of this would be assigning values to an array of data structures. The Lattice C compiler would calculate the address of the referenced structure element once and use it as a base address for each of the assignments; the Aztec C68K compiler would recalculate the base address each time it was used, even if the same base address was used 10 times in a row.

Aztec C68K goes into overdrive for benchmark speed when you use *16-bit integers*, particularly if you make appropriate use of register variables. This speed is best demonstrated in the Sieve benchmark, in which Aztec C68K finished in 2.6 seconds compared to 3.8 seconds using 32-bit integer size, which was identical to the time Lattice C posted.

The one benchmark that neither

(continued)

Table 2: *Benchmark timing and file size results. All times are in seconds, and all file sizes are in bytes. A dash indicates that timings were not available. The benchmark programs are available from* BYTEnet Listings at (617) 861-9764.

	Aztec C68K (16-bit)	Aztec C68K (32-bit)	Aztec C68K (16-bit with registers)	Aztec C68K (32-bit with registers)	Lattice C	Lattice C (with registers)
Sieve						
Compile	15	15	14	15	48	49
Link[a]	25(130)	24(130)	25(131)	25(130)	61	60(130)
Execute	4.6	5.8	2.6	3.8	5.8	3.8
File Size	5496	5508	5444	5456	16,320	16,284
Fib						
Compile	18	18	—	—	48	—
Link	24	25	—	—	60	—
Execute	19.6	22.6	—	—	22.7	—
File Size	5460	5468	—	—	16,280	—
Sort[b]						
Compile	22	22	22	22	60	60
Link	26	26	26	26	61	61
Execute	9.3	9.8	7.9	8.9	9.6	8.5
File Size	9912	10,092	9836	10,016	20,800	20,756
Float						
Compile	18	—	—	—	49	—
Link	30	—	—	—	61	—
Execute	15.9	—	—	—	118.3	—
File Size	6840	—	—	—	16,772	—
Fileio						
Compile	24	—	—	—	55	—
Link	27	—	—	—	61	—
Execute	1812	—	—	—	2522	—
File Size	7004	—	—	—	17,332	—
Savage[c]						
Compile	17	—	—	—	47	—
Link	32	—	—	—	62	—
Execute	9.9	—	—	—	234.5	—
File Size	6688	—	—	—	23,376	—

Accuracy
Lattice = 2.4999999996836e+03
Aztec = 2.72685551643371e+3
(perfect = 2.5000000000000e+03)

[a] For Aztec C68K, the slower (parenthesized) time is the time required to link with the library on disk; the faster time was achieved using the RAM disk. For Lattice C, the slower time was the normal time, but the faster time was the result of including the keyword **faster** at the end of the linker command line.

[b] It is necessary to increase the stack size to run this benchmark with either compiler. I used **STACK 40000**.

[c] A floating-point math benchmark on the Amiga may be slower on the first execution because the libraries must be loaded from disk. Lattice C's size differential is partly due to the Mathtrans library; Aztec C68K uses the Amiga system run-time library, which is about 4.5K bytes. Lattice C uses its own double-precision IEEE routines in object code. The Savage benchmark is from *Dr. Dobb's Journal*, September 1983, page 120.

compiler could do well in was Fileio. There are two problems in this area. The first problem is that AmigaDOS simply does not handle random disk I/O very well. The second is that the multitasking routines do not handle single-character I/O well.

I will explain the second problem first. In the multitasking environment, any disk I/O request must pass a message to the disk device driver, which then goes out and handles the request. Then the driver returns a message to the task that made the request. This same overhead occurs whether your request is for a single byte or for 100K bytes. In a multitasking environment, this overhead allows many different tasks to access the same disk and files concurrently without problems. The Fileio benchmark does a lot of single-character I/O operations, which is the worst-case performance category for the Amiga. A simple solution for programmers is to make requests for as large a chunk of data as possible at a time. The Amiga disk can pump data at about 8K bytes per second if you make requests for large blocks.

The first problem, random disk I/O under AmigaDOS, is actually two problems: AmigaDOS is slow, and the Amiga is a track-buffered machine. I can't explain AmigaDOS, but I can explain the track buffering: Any I/O read or write actually brings a whole track (about 15K bytes) of data into the machine. The Amiga is very efficient at doing that, with a raw data speed of about 20K bytes per second, but when doing random disk I/O this scheme runs counter to productivity.

A partial solution to the random disk I/O problem will probably be fixed soon: Amiga is preparing to release version 1.2 of AmigaDOS. I ran the Fileio benchmark with this version, and the results were more than twice the speed of the results obtained using version 1.1.

THE MANX AZTEC C68K PACKAGE

The Aztec C68K compiler has both a Developer version and a Commerical version. Both versions include the compiler and assembler, Manx's linker, the Amiga include files, a set of example programs from public domain disks, and Manx's linker libraries.

The Developer version has the same compiler, assembler, linker, and library routines as the Commercial version. It has a suggested retail price of $299.

The Commercial version has a set of utility programs and includes source code for the libraries and a set of extended library functions. Among the utilities are a MAKE facility, a debugger, and a vi-style text editor, as well as DIFF, GREP, and library and archive programs. Also included with the Commercial version is a year of free updates. The suggested list price is $499.

I found the MAKE facility to be quite useful, although it is missing some features that are available in other MAKE programs. Also, I consider having the library sources indispensable for professional developers, both as a way of verifying that the libraries are doing exactly what you think they are and as a source of examples.

THE LATTICE C PACKAGE

Lattice Incorporated offers a native Amiga C compiler that has a suggested retail price of $149.95 and an IBM PC cross-compiler that has a list price of $250.

Included in both Lattice C compiler packages are the two passes of the compiler, LC1 and LC2; the linker ALink; the Amiga include files; the Lattice linker libraries and start-up files, as well as some examples; and the Lattice Object Module Disassembler. Lattice also has a set of utility programs similar to those available in the Aztec C68K Commercial version, but Lattice sells them individually rather than as a package.

ALINK

ALink is the standard linker for the Amiga developed by Metacomco (which also developed AmigaDOS). It uses Metacomco's standard object code and library format.

ALink has a couple of major problems: First, it is extremely slow. Second, it has limitations based on available RAM that determine the size of the file that can be linked. That in itself isn't so bad, except that it brings all the input modules, including libraries, into RAM for linking.

ALink creates one of the biggest differences between Lattice C and Aztec C68K in terms of development time. Since Manx Software Systems has its own internal object and library format, it does not suffer this problem. The result is a clear-cut advantage for the Aztec C68K compiler until somebody does something to solve the ALink problems.

Dale Luck at Amiga has implemented a partial solution for ALink; he discovered that ALink spent most of its execution time in allocating and deallocating memory. He came up with a quick fix (which is included in version 2.3) that you can invoke by adding the keyword faster to the end of your ALink command line. This doubles the speed of the link process. The only penalty is that ALink may not be able to run at this point because it grabs a single large chunk of memory at the start of execution.

Even with the faster option, the Aztec C68K's linker is about twice as fast as ALink, and linking is the slowest part of the development process. But it's a start.

DOCUMENTATION

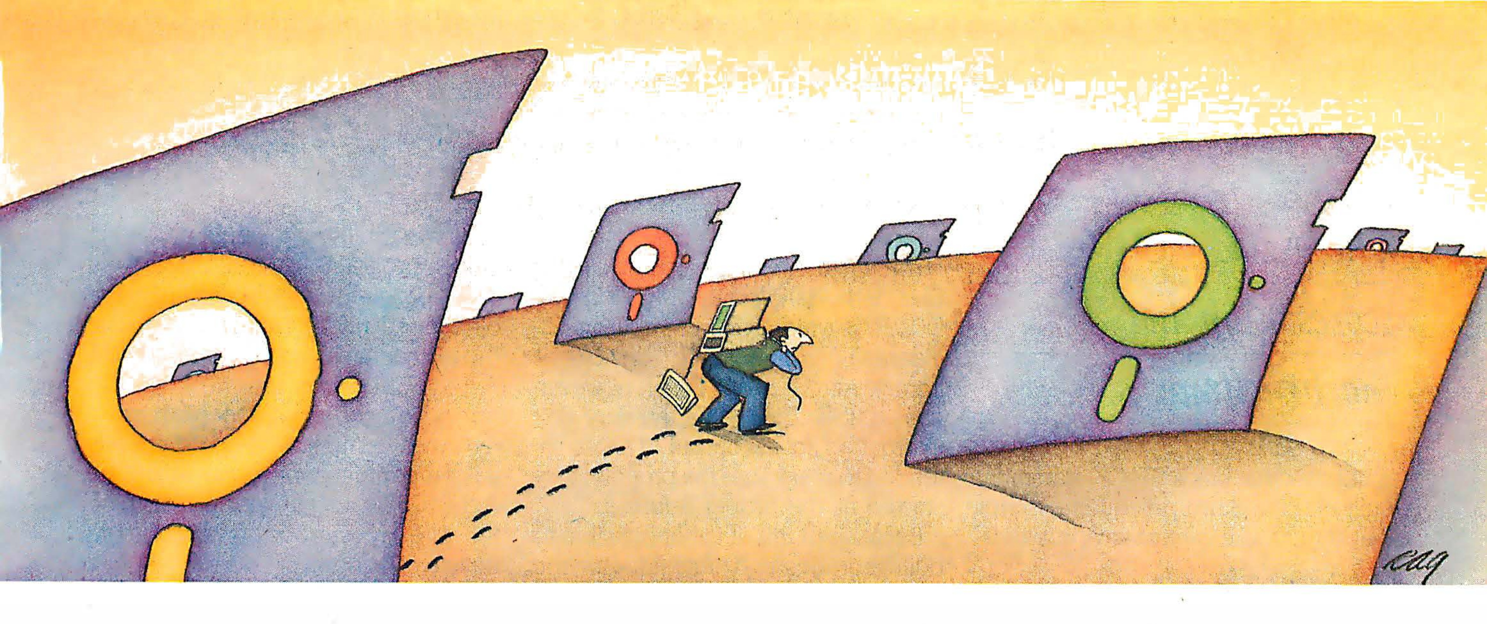
The documentation that comes with both compilers is more like operator's manuals than anything else. Both include reasonable instructions for operating the various programs included with the packages and instructions for the various compiler switch options.

You'll need Amiga-specific information if you plan to write programs that go beyond the standard C library I/O functions. The Amiga technical manuals are the best set of references available for the Amiga.

RELIABILITY

Another issue to be considered is the reliability of these compilers. Fortunately, both get high marks, but you should take the precaution of allocating sufficient stack space when you compile with Lattice C by using the AmigaDOS STACK command. The Aztec C68K compiler comes on

(continued)



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BPI				

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Inquiry 305

The Aztec C68K scores high in the benchmarks.

a CLI disk that has a STACK statement built into the Startup-Sequence script that should take care of any problems.

MISCELLANEOUS

One additional problem is the Aztec C68K's use of 16-bit integers. It is difficult to develop for the Amiga using 16-bit integers because the resident libraries expect 32-bit values as input arguments; thus, nearly all Amiga function calls must have casts to (long) when compiling using 16-bit integers.

On the other hand, Aztec C68K has a 32-bit compile mode that is very nearly identical to Lattice C in terms of the source files it will accept as input. For most of the public domain programs that are available, it is possible to compile them without modification using Aztec C68K's 32-bit compile option and the supplied 32-bit linking libraries.

Another problem is an issue with Aztec C68K's linker. The Amiga device drivers and libraries require a vector table offset by 4 bytes from the start of an executable object file. Normally, the first code in library and device files is a safety net, MOVEQ #0, D0 ; RTS, which protects you from accidentally running the device or library. Aztec C68K's linker, however, uses a JSR .BEGIN as the very first instruction in its output. This is intended to make sure the program gets started at the proper address.

Because of this, it is not possible to build libraries and devices with the current version of the Aztec C68K compiler. Manx Software Systems has assured developers that this problem will be solved in an update.

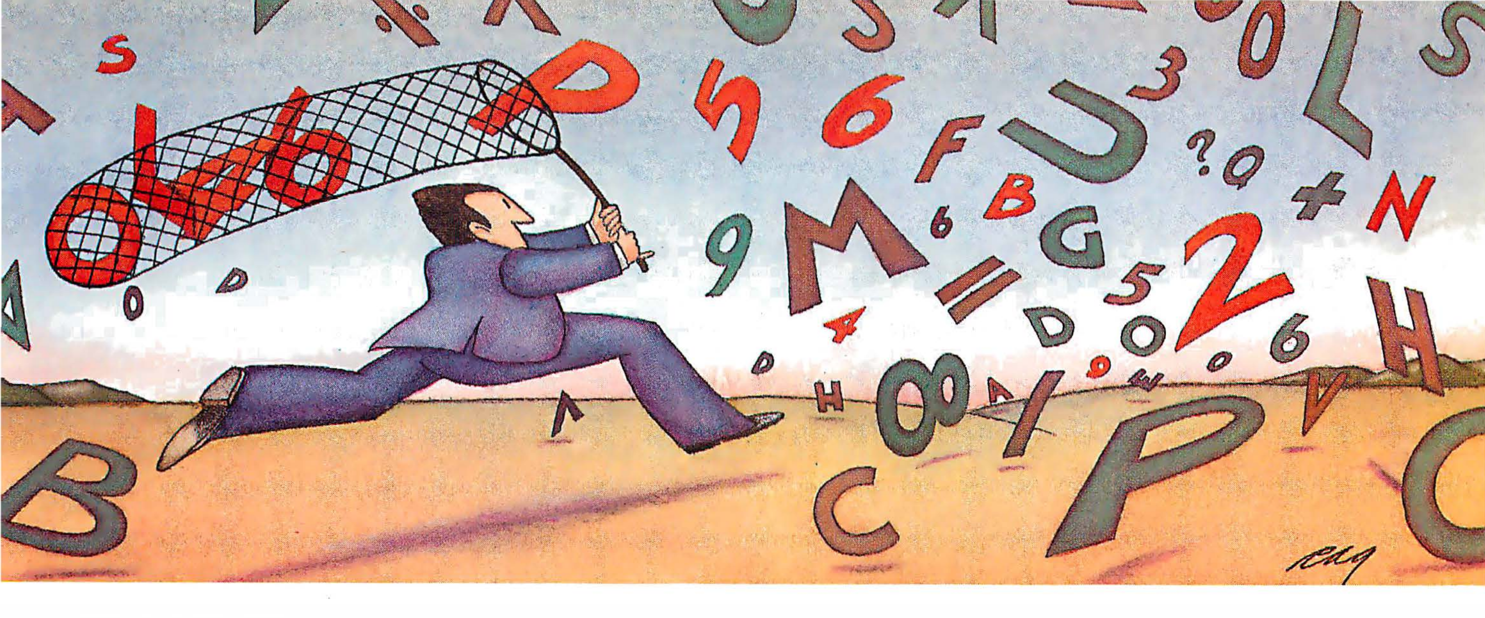
CONCLUSIONS

Both Lattice C and Manx Aztec C68K compiler provide tools for professional developers and hackers alike.

The Aztec C68K scores high in the benchmarks, particularly in terms of code size and compile/link time. High marks also go to Manx Software Systems for providing the source code for the library functions, which I consider essential for professional developers. Another big advantage in using the Aztec C68K compiler is that the programs needed for compiling require about half the disk space as those of the Lattice C compiler. (This includes the assembler, which is not a part of the Lattice C package.)

The Lattice C compiler scores high in compatibility with public domain Amiga programs because most of the early programs for the Amiga were developed under Lattice C. Most of those programs can be compiled with Aztec C68K if you use the 32-bit option, but as of now if there is a problem with compiling; it is more likely a compatibility problem with the Aztec C68K. Lattice also scores high for already supporting the Amiga device driver object code format and for supporting the scatter-loading philosophy, which is important for large programs with a lot of graphic memory requirements. Lattice should also continue to benefit from its close relationship with Commodore.

Both compilers have room for improvement. Lattice needs to reduce the size of its compiler and needs to find a solution to the slow linking problems inherited from ALink. Lattice also needs to support relative addressing so its compiler can generate small code. Manx Software Systems' biggest problem is adapting its linker so it will work better with the Amiga's specific needs for scatter-loading of object code. Aztec C68K also needs to support device and library object code formats. I relish the thought of seeing a better code optimizer for the Aztec C68K, which should improve its already impressive benchmark results. ■



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Inquiry 296 for End-Users. Inquiry 297 for DEALERS ONLY.

SPSS/PC+

BY JEFFREY M. JACQUES

A high-quality analytical and statistical production tool

The SPSS/PC+ analytical software package by SPSS Incorporated consists of three modules: the base system and two options, Tables and Advanced Statistics. It is a substantial but incomplete subset of SPSS-X, its mainframe cousin. PC+ has word-processing and database management capabilities, but it shines in providing a wide variety of analytical tools, testing logical conditions, transforming data (such as logical IFs and calculating new values), and computing a wide range of descriptive and inferential statistics. It can do almost everything that you could want a sophisticated analysis package to do, and it does so with reasonable speed.

PC+ is a series of well-integrated FORTRAN, C, and assembly language modules organized in a three-level hierarchical structure. At the first level, the SPSSPC.COM file controls the links to DOS, command and data files, PC+ overlays, and other modules. On the second level, the secondary modules, written in FORTRAN, provide most data management and user links. This is where you set user-defined parameters, access HELP if you forget a command, execute statistics, and generate reports. The third level, written in C, consists of SPSS Incorporated's enhancements to the product, notably the full-screen editor, Review. Everything I ran with this system executed as expected with reasonable speed, error trapping, and user control. You even have the option of directing which of the statistical modules remain on disk and which can be deleted.

COMMANDS

PC+ has three basic types of commands: operation, data definition and manipulation, and procedure commands. Usually, the operation commands will be listed first, followed by the data definition and manipulation commands, and then the procedure commands. Each command type is divided into two major sections: the keyword and the specifications. The keyword begins with a unique name, of which at least the first three characters must correspond exactly to a PC+ command. This tells PC+ which modules to load and which procedures to execute. The specifications contain any detailed information required by the command, such as variables or data; for example, TITLE 'TEST OF SPSS PC+'. The keyword TITLE indicates that you are setting up a title to appear on each page of your output, in this case, TEST OF SPSS PC+. The period at the end of the command, called a terminator, is required for each PC+ command.

Some commands may require several lines of code while others may need additional information. To invoke PC+ options, your command might look like this:

```
FREQUENCIES VARIABLES=AGE
  INCOME
/FORMAT = CONDENSE
/HISTOGRAM
/STATISTICS = ALL.
```

In this case, FREQUENCIES produces a simple frequency distribution that lists each value, the number of times it occurred, the percent of the total, and a cumulative percent. The subcommands have similar uses: VARIABLES lists the variables that this run of the procedure will examine, FORMAT structures the tabular display, HISTOGRAM produces a histogram for each variable, and STATISTICS computes and reports the requested statistics—in this case, ALL the summary statistics. These subcommands are generally required when you want the procedure to perform specific computations or produce one or more tables or charts. Most command names and subcommands are straightforward and follow this structure.

Commands can become quite long and complex since PC+ is command-driven. This is especially true if you create complex REPORTS or run complex REGRESSION analyses. Furthermore, you must explicitly follow the rules (e.g., syntax, naming conventions, and order of commands). In some cases, you may need to create command files several hundreds of lines long. Therefore, it is advantageous to create a separate command file and a separate data file for program execution.

EDITOR

The PC+ editor, Review, is a good, basic, easy-to-use full-screen editor that can hold up to 64K bytes of RAM, writing any overflow to disk. Review uses a Microsoft Windows approach with a split screen—the top half of the screen lists the end of your resulting output, if any, and the bottom half lists your log, or command, file. With a color monitor, the different windows are clearly defined and quite easy to work with.

(continued)

Jeffrey M. Jacques is a professor in the Department of Sociology, Criminal Justice, and Social Welfare at Florida A&M University (Tallahassee, FL 32307).

SPSS/PC+

Type
Statistical and analytical environment

Company
SPSS Incorporated
444 North Michigan Ave.
Chicago, IL 60611
(312) 329-2400

Format
Eighteen 5¼-inch floppy disks

Computer
IBM PC, XT, AT, or compatible with 384K bytes of RAM and a hard disk; DEC Rainbow–class computers similarly configured

Features
The base system contains the editor, Review. Its analytical system provides the following capabilities: frequency distributions, summary statistics, bar charts and histograms, contingency tables, breakdown of population by subpopulation summary statistics, one-way analysis of variance, regression, multiple regression, and nonparametric procedures. The optional Tables module provides tabular output for single-variable and multiple-variable tables and summary functions and statistics. It gives you complete format control. The optional Advanced Statistics module enables discriminant analysis, factor analysis, cluster analysis, multivariate analysis of variance, repeated-measure analysis of variance, and log and linear models. Both Tables and Advanced Statistics require that the base system be installed.

Documentation
More than 1000 pages of well-developed information appropriately divided among applications, user's guide, and reference materials.

Price

Base system:	$795
Tables:	$295
Advanced Statistics:	$295

If you forget any of the edit commands, you can easily get help in a window overlay by simply pressing the F1 key. With a color monitor, it is easy to tell the document characters from the Help menu; with a monochrome display, however, it takes some practice. In general, if you have worked with a full-screen editor before, you will be able to master Review in a couple of hours.

Alternatively, you may wish to create necessary files with your favorite word processor or spreadsheet software, as I did. Small fixed-format data files are probably best created with a standard spreadsheet package where you can PRINT a file to disk, eliminate all special characters and headers, and make sure that the output displays all the values in each record. Most spreadsheet packages are limited to approximately 250 characters per record, while PC+ can read as many as 1024 characters per record. Large data files are probably best created with a standard database program. You simply create a standard ASCII data file and make sure to note the beginning and ending location of each field so that you can define the data fields for PC+.

GETTING STARTED

To begin, you need to create a directory on your hard disk, load the SPSS/PC+ software from the 18 disks, and build a CONFIG.SYS file to increase the number of buffers and the maximum number of files that you can have open at one time. It is also helpful to build a batch (.BAT) file for easy access to PC+. Some knowledge of MS-DOS is essential.

PC+ analysis requires creating and manipulating several files: a command input file containing all your PC+ commands, a data file, an SPSS.LOG file that contains a list of all your commands and PC+'s action on each, SPSS.LIS, which contains a copy of what is displayed on the screen and can be printed, and SPSS.SYS, a systems file that contains the transformation of your data and data dictionary so that PC+ can process more quickly.

In addition, PC+ creates files for its own use, for instance, an active systems file for the data set being used or a command-summary file if you use the editor. More files are created if you use PC+'s portable files for export to mainframe SPSS-X systems or if you use PC+'s output files for writing your correlation matrices or transformed data. If you execute the command SHOW, you can see a listing of most filenames and conventions in a simple table. You can change these options with other commands.

BOOTING AND RUNNING

When you boot PC+, you will see its logo and then the SPSS/PC: prompt. The entry INCLUDE '\path\filename.suffix'. retrieves all essential commands from your command file. As each command is read from the INCLUDE file, PC+ echoes it to the screen and then executes it. If you make any errors, PC+ will notify you by beeping and indicating the error's location and type, and sometimes even the offending characters.

To correct an error, you enter REVIEW. at the SPSS/PC: prompt to get to the editor. You use the cursor control keys to locate the error; then you correct it. Next, you MARK a BLOCK (indicate the beginning and end of the PC+ commands) and exit the editor. PC+ automatically notes the changes, lets you change the filename if you want, saves the marked block section of the file to disk, and reexecutes the commands. You don't need to delete any intervening PC+ comments. When you get the command file the way you want it, PC+ executes your commands and sends your results to the screen, printer, disk, or all three.

Review is particularly useful when you have to make a few corrections to a large and complex command file. It is also useful for browsing through the output listing file and examining the results of commands before you print them. While PC+ is not a traditional database manager, it can merge files, key on specific variables when joining files, sort a file, make simple retrievals and report listings, and develop complex reports as well as most database programs can.

The output of the PC+ system is

logically split between useful information about the command that is executed and the results of the execution. The maximum amount of appropriate information is on the screen at all times. If a table won't fit on one screen, PC+ divides the output at a logical place and prompts you that there is MORE information. It then displays a new screen if you press an input key.

You can also turn off the screen and print all results to a disk file or to the printer. Setting PRINTER=ON and SCREEN=OFF permits you to print the results without seeing the MORE information message. If you are familiar with mainframes or minicomputers, you may appreciate this option. You have full control of the length and width of the output so that you can change the page size to wide output (132 columns) and set an appropriate page length. (For such an output, you need to use the DOS MODE printer command as well as the PC+ commands LENGTH and WIDTH.)

PC+ can also share data with other software and other computers. Beyond writing results to an external ASCII file, it can share systems files and most of its commands with SPSS-X release 2.1 via a porting facility. Be prepared to make several changes in syntax and structure if you port just a copy of the command file, however.

You can impressively increase PC+'s execution speed if you convert all your ASCII data and command files to a systems file. Once created, this file brings substantial time savings in processing time and in the ease of using the interactive mode. With a GET command to identify which systems file to use and a procedure keyword and specifications to identify any unique run, PC+ can process your data and compute your statistics.

SPSS/PC+ AND SPSS-X

Using SPSS/PC+ is similar to using its mainframe/minicomputer cousin, SPSS-X, but there are also some notable differences. Working with both can be confusing. I found myself using commands that were not appropriate and having to use slightly different syntax. Here are some examples:

- Not all the procedure commands use the same keyword names. SPSS-X calls a temporary data modification TEMPORARY while PC+ calls it PROCESS IF. Similarly, SPSS-X uses BREAKDOWN to examine subpopulation means and standard deviations while PC+ uses MEANS. Although aliases are provided, there is no apparent reason to use two different command names to run the same procedure.
- Not all procedure commands use the same structure. PC+ commands require a slash when you issue a subcommand while SPSS-X commands do not.
- Some of the procedures available in SPSS-X (e.g., RELIABILITY) are not found in PC+, nor are some of the SPSS-X command options available in PC+. For example, COMPUTE doesn't allow statistical functions, and you cannot RECODE a set of values for one variable into a new variable.
- Even when the same command name or structure is found, it may not have the same options, or the options may mean different things (e.g., the logical expression TRUE OR MISSING is treated as TRUE in SPSS-X and as MISSING in PC+).
- PC+ requires a period at the end of a command; this is an error condition in SPSS-X. This will probably produce the most frustration for the experienced SPSS-X user.
- In PC+, a command continuation can begin in column 1 of the following line, while in SPSS-X use of the first character position is interpreted as the beginning of a new command.
- PC+ allows fewer possible variables in any one file—200—while SPSS-X allows access to many more.
- The DATA LIST command, which defines the specifications of the data file, is different in form, power, and options for the two programs. In PC+, data-file location is listed, data-file format is limited to fixed, free-field, or matrix (no hierarchical files are possible), and FORTRAN-like specifications are not accepted.

Despite these differences, PC+ has some nice features that are not available in SPSS-X. Most importantly, PC+ has an on-line HELP facility where general information about commands, keywords, and their options is available. The DISPLAY command lists descriptions of all the variables in the active file (such as variable names, labels, and type). The SHOW command summarizes the SET command's chosen options and displays each on the screen. Finally, PC+ has on-line error prompting and the editor, Review.

WHAT'S MISSING

A real problem with PC+ comes from porting a mainframe program and trying to maintain its integrity on a microcomputer. First, PC+ relies exclusively on a command-driven mentality. It has no user prompts or simple menus. While help is available, PC+ erases the screen before giving you an answer. Thus, you cannot easily compare what you were doing with the available HELP options. It's easy to lose the thread of what you were working on and the appropriate fix.

In its attempt to keep mainframe integrity, SPSS Incorporated has lost touch with how many microcomputer users use desktop computers and what they expect of software in terms of user-friendliness and integration. While the access to powerful analytical routines is important, today's microcomputer user expects a user-friendly package. PC+ can't claim user-friendliness as long as it relies on a command-driven system.

Second, PC+ is missing some important application modules. Data entry is abysmal: It has no database data-entry system, not even a simple spreadsheet data-entry routine at the time of this writing. You can't invoke the on-screen editing capability for the processing options, even though it's listed in menu format. PC+ does not support either a subfile structure or a hierarchical file structure as SPSS-X does. PC+ can't easily select a subset of cases for analysis when you need to select on multiple variables but don't wish to permanently alter the file. (It has no easy access to the SPSS-X TEMPORARY command structure.) You can't use ProKey or SuperKey macros or Microsoft Windows if you are running the larger

(continued)

modules with many variables. SPSS Incorporated recommends that you remove all RAM-resident routines before entering the PC+ system.

WHAT YOU NEED

To run PC+, you need an IBM PC, XT, AT, or compatible microcomputer with a minimum of 384K bytes (more if you plan to run the Advanced Statistics option), a 10-megabyte hard disk, PC-/MS-DOS 2.1 or later, and a monitor. These are the minimum requirements. I recommend an IBM PC AT or compatible with 640K bytes, a 20-megabyte hard disk, a math coprocessor, a color monitor, and a high-speed printer. PC+ uses all available memory up to 640K bytes and requires extensive secondary storage; the complete package uses about 6.5 megabytes just to store its software. Computational scratch files and extensive outputs can consume another megabyte or two. A 10-megabyte hard disk is too small if you plan to use word-processing, spreadsheet, and database packages along with it.

As an analytical tool, PC+ is calculation-intensive and uses a math coprocessor extensively if you have one. This significantly speeds up execution time on a PC XT–class machine. A color monitor facilitates working with the editor, and a high-speed dot-matrix printer saves time since you can easily produce large outputs.

While this is what I recommend, I used an IBM PC compatible running at 4.77 MHz, 640K bytes of RAM, a 20-megabyte Everex hard disk, MS-DOS 3.1, a color graphics adapter card, and a color monitor.

WHAT YOU GET

The $795 SPSS/PC+ base system includes enough statistical power and reporting facilities to take care of the needs of most mid-level analysts. It contains everything from simple reporting and listing routines and descriptive statistical routines (such as frequency distributions, contingency tables, and bivariate correlation analysis), to simple and multivariate regression analysis. Although the base system comes with an editor, you may want to use your favorite word-processing, spreadsheet, or database software when building command and data files. The base system also comes with a tutorial disk.

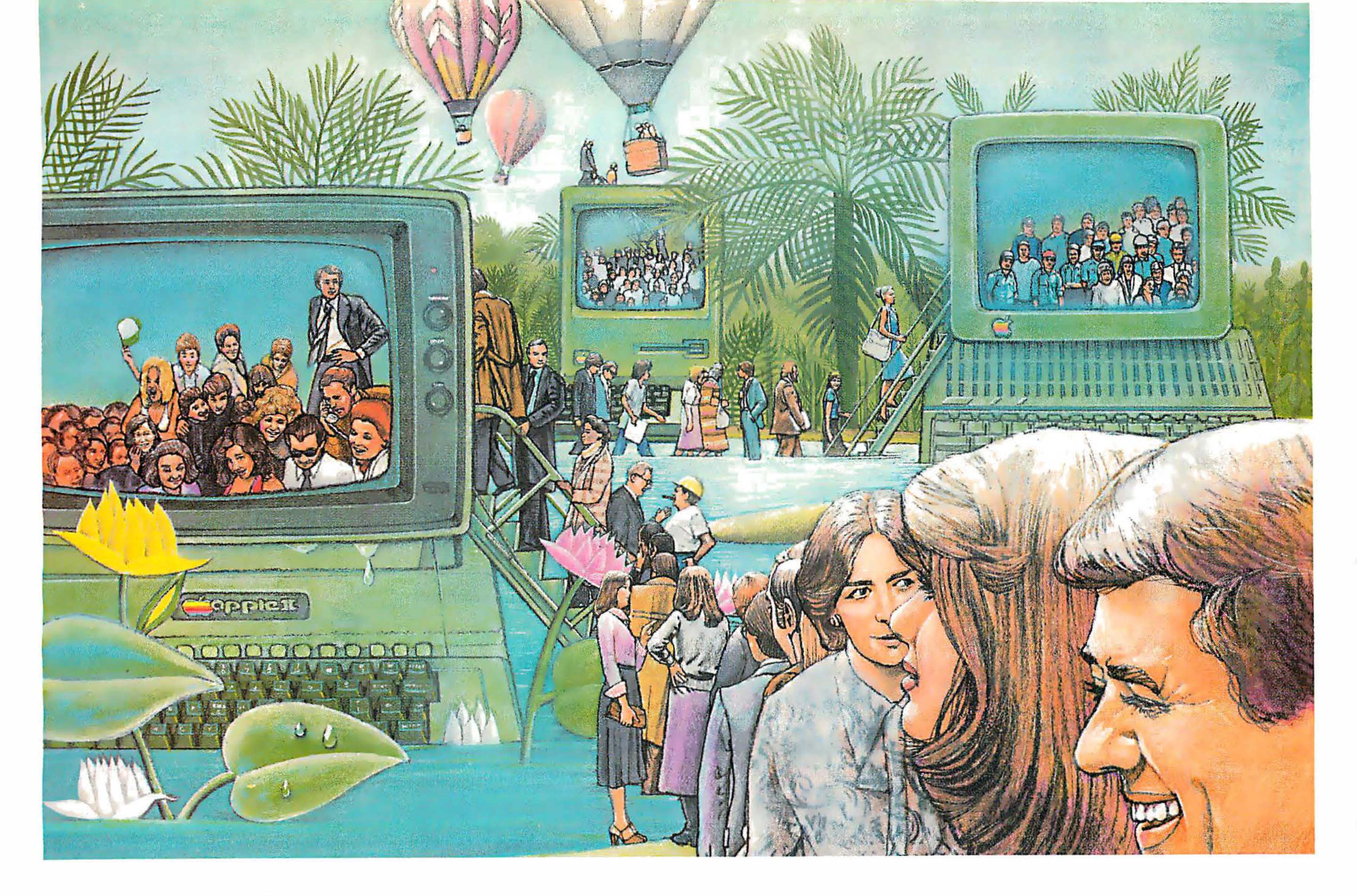
Tables ($295) produces high-quality tabular displays that you can incorporate directly into your word-processing document. Standard PC+ outputs are generally tightly structured with little user discretion on form and style. With Tables, however, you have more control. For example, with this option you can display frequencies, percentages, and summary statistics for multiple variables in the same table; without it that information would take several pages. Even though Tables has this power, it is probably the most overpriced part of the package; if you are adept at using a word processor, you can create a similar structure fairly quickly by modifying the standard PC+ results.

Advanced Statistics ($295) was designed for the advanced user. If you need to run factor or cluster analysis or just about any of the more typical complex procedures, you will find this option a reasonable investment.

The documentation for each package is well written and extensive. Each package comes with its own similarly structured manual, complete with step-by-step instructions, examples, a glossary, and an index.

CONCLUSION

SPSS/PC+ is a high-quality analytical production tool for IBM PC and compatible microcomputer systems. It does have its limitations, particularly when compared to its mainframe cousin, SPSS-X. For instance, it is not very user-friendly. But it does provide sophisticated statistical analysis along with a full-screen editor and data management capabilities. With its help function and on-line error prompting, PC+ can handle almost any analytical task you would need. ■



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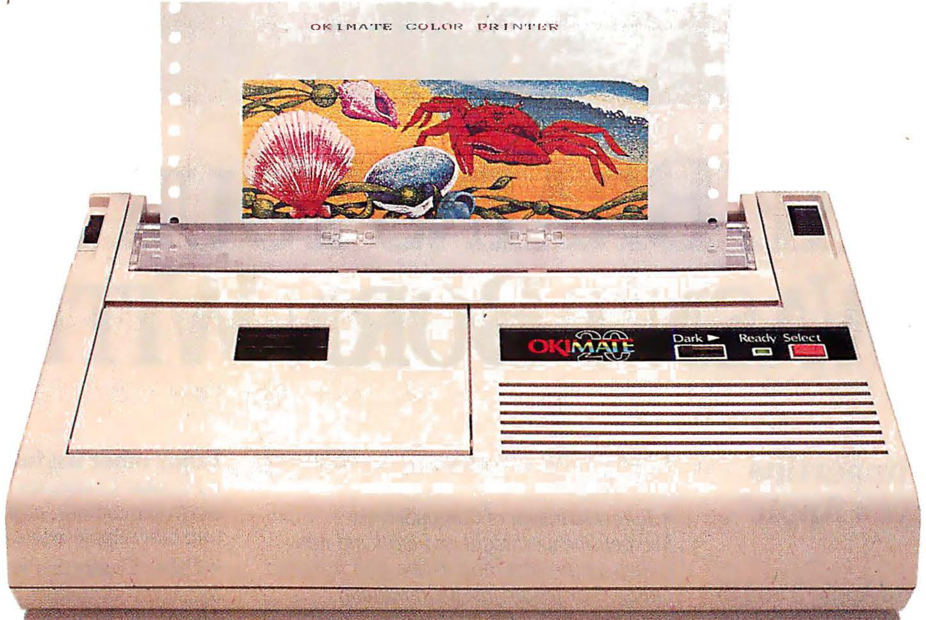
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Aegis Animator and Aegis Images

BY WARREN BLOCK

Color graphics paint and animation software for the Amiga

Aegis Development Incorporated's Animator is a software package for the Amiga that lets you create animated video sequences. Included in the package is Aegis Images, a full-featured paint program that works in conjunction with Aegis Animator. Images is also available separately.

Both packages need a minimum of 512K bytes of memory to operate, support multitasking under the Workbench, and use the IFF format developed by Electronic Arts to create files that can be used with other programs. Only one floppy disk drive is necessary because both programs are memory-resident. It is feasible to run both programs at the same time, although this requires at least a megabyte of memory.

AEGIS ANIMATOR

The Aegis Animator system is based on "tweens," which are short segments of time in an animation during which something happens. Imagine a square that rotates from one side of the screen to the other. Instead of defining this as several individual frames in which the square is shown in different positions, which is the traditional approach, you tell Animator where the square will be and how much it will have turned by the end of the tween. The program then takes care of redrawing it in the appropriate places to create the illusion of movement. This technique of tweening makes animation surprisingly easy—Animator does all the work.

MANIPULATING SHAPES

Shapes created with Animator are essentially lists of vectors, much like Apple II shape tables. Because these shapes take fewer calculations to redraw than ordinary bit-mapped pictures, actions such as rotations and size changes can occur fast enough for real-time motion. Some shapes that Animator can create include polygons, lines, circles, and stars. (Rectangular items, called blocks, can also be created, but these are related to windows and masks, which I will describe later.)

Many options for manipulating shapes are provided, including rotating in the plane of the screen, around the *x* axis or the *y* axis, and changing a shape's size or color. You can combine several of these actions in a single tween to create very complicated movements. For instance, you can rotate and shrink a shape, creating the illusion of movement into the distance. You can view objects as solid shapes or in ghost mode, in which only their outlines are drawn. This makes it easier to work on objects that are overlaid by others.

A very impressive feature, called Morph, lets you change the shape of objects by moving the geometric points that compose them. You can even add new points to an object or delete those that already exist. It took me only seconds to create a star that "morphed" across a space into a smaller star during one tween. The resulting animation showed the star flowing like paint across the intervening space and forming into the second star. It is a visual effect that, while difficult to describe, is familiar on the screen—it looks very much like an effect out of a cartoon.

CONTROL OF BLITTER OBJECTS

Aegis Animator is capable of creating bit-mapped objects (other than background pictures) or loading objects that have been created with a paint program like Aegis Images. These bit maps include, in the program's own terminology, blocks, windows, and masks. Both windows and masks are segments of bit-mapped drawings (masks are similar to windows, but are limited to one color); blocks are simply rectangular bit maps with no details. All three are blitter objects that can be moved about by the Amiga's blitter chip more quickly and smoothly than Animator's vector-drawn objects. Because they are bit-mapped shapes, however, rotations require too many processor calculations to allow them to be shown in real time.

COLOR

The Amiga is a color computer, and Animator, which works in the Amiga's 32-color low-resolution mode, is not lacking in this area. Colors can be defined, saved in a file, and then reloaded for an animation. You can fade a range of colors into another color so your latest animated epic can fade to black, white, or any other color at

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Warren Block (645 King St., Chadron, NE 69337) currently comprises the entire computer repair department of Chadron State College.

Aegis Animator and Aegis Images

Type
Animation software and paint program

Company
Aegis Development Incorporated
2210 Wilshire Blvd., Suite 277
Santa Monica, CA 90403
(213) 306-0735

Format
Two 3½-inch disks; not copy-protected

Computer
Commodore Amiga with at least 512K bytes of RAM and one floppy disk drive

Documentation
Inside Aegis Animator, 99 pages;
Inside Aegis Images, 84 pages

Price
Aegis Animator and Aegis Images: $139.95
Aegis Images: $79.95

its completion. You can use the Spectrum function to create a rainbow of colors, while the Cycle function makes color go through a set of shades during a tween. The Range function creates a range of shades between two colors.

Scripts

The complete set of tweens that makes up an animation is called a script. Script files are stored on disk as ordinary text files that are composed of instructions in Animator's own language. To execute an animation, the program actually interprets these files, very much like the intermediate p-code used by many Pascal compilers. You can even write programs in Animator's language: Information about it is available from Aegis Development Incorporated. While the speed lost in the interpretation process has been the downfall of several Pascal compilers, Aegis Animator often needs to be slowed down to keep complex movements from becoming so fast that only a flicker is displayed.

Memory Use

Script files don't use much memory, but the manner in which Animator runs them does: All the backgrounds and windows used by a script must be loaded into memory before that script can be executed. This is done so the real-time animation doesn't need to stop for disk access. For this reason, however, a script file that takes up only 18.2K bytes of storage space on disk actually needs more than 39K bytes to execute. In an Amiga with 512K bytes of RAM there is enough memory to create fairly sophisticated animations, especially if there is not more than one background picture, but another 512K bytes or more would definitely be helpful. If you plan on creating animations that will take more than two minutes of real time, plan on adding memory.

Fast Menu

To make using Aegis Animator easier, a Fast Menu is provided. This is a small window that contains icons representing menu choices. Clicking the mouse button on one of these icons provides a shortcut to a menu selection.

At first it seems that this feature is more of an annoyance than anything else—the window continually gets in the way. However, as the program's operation becomes more familiar, the Fast Menu's usefulness grows more apparent. The window can be moved or closed if necessary, and it is much more intuitive and faster to click on an icon in the Fast Menu than to select a menu option from the menu bar at the top of the screen.

Useful utility functions abound in Animator, including Undo, to negate the last action taken; Move-In and Move-Out, to move objects behind or in front of others; control of elapsed time in a tween or for a whole script; and numerous others.

Storyboard Editing

You edit scripts through Animator's Storyboard. When you select the Storyboard from the main menu or click on its icon in the Fast Menu, the screen is divided into nine equal windows. The script that was just being worked on is shown, scaled down, in one of these windows. Using Storyboard options, parts can be cut off a script, moved into their own windows, spliced together again, or deleted from memory altogether. You can execute these scaled-down scripts individually or several at a time. This certainly looks impressive, but as an editing function it is not really very useful.

Aegis Images

Aegis Images, the painting and drawing program that comes with Animator, has all the standard features you'd expect from this type of program. You can draw geometrically or freehand with different brushes in 32 colors. You can use any of 16 patterns to draw or fill figures or use custom patterns created with the built-in editor. The program slows down quite a bit when you use the patterns for drawing, however.

All these features are fairly standard; much more interesting are the unusual extras. You can frame a section of a drawing in a window and

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then rotate and scale it to different proportions. Using the Spread option, you can fill areas with a range of colors so that one color fades into the next. This can result in some spectacular visual effects with practically no effort. With the Wash and Smear features, colors can be mixed together like paint. The Antialias function smooths out rough edges around shapes by using color to simulate higher resolution. Parts of a picture can be used as a brush, and you can design special brushes with the built-in editor. You can cycle colors repeatedly through a range of shades to create animated scenes.

Window, mask, and color files created by Aegis Animator can be loaded into Aegis Images for editing, or you can simply use Images to create them in the first place. Although Images does not have Animator's Spectrum option, you can simulate it by creating a set of colors with Animator, saving them to disk, and then loading them into Images.

INTERFACE DIFFICULTIES

Aegis Images' user interface is somewhat more polished than Animator's, but its Fast Menu is not as useful, nor does it get in the way as often. A few difficulties arise from the difference between the two programs. For instance, to define a window with Images, you click the mouse's Select button on the first corner, move the pointer to the second corner, and click the Select button again. In Animator, you click the Select button on the first corner and hold it down until the pointer reaches the second corner. This can cause confusion when switching between the two programs, but both Images and Animator have an Undo feature that can correct mistakes to some degree.

All in all, Images is a likable program that does what it should with no problems. There are lots of powerful options, and the user interface works smoothly, even if it is different from Animator's.

Both Animator and the copy of Images included on the distribution disk use the Amiga's low-resolution graphics mode (320 by 200 pixels). There is also a high-resolution version (640 by 200 pixels) of Images that you can obtain separately for $10 extra. The low-resolution 32-color mode of the Amiga is good enough for most applications. With careful thought, you can avoid rough edges around shapes or make them less noticeable, and that is really all that a higher screen resolution accomplishes.

DOCUMENTATION

Included with the Aegis Animator/Images package are two softbound books, *Inside Aegis Animator* and *Inside Aegis Images*. Both are nicely done with good indexes and organization, but they have a nontechnical slant that is rather frustrating at times. For example, the only place that specifies that 512K bytes of memory is necessary to run the programs is the box that the package comes in.

SUGGESTIONS

There are only a few changes that I would like to see made to these graphics tools. More examples would be very helpful, especially scripts for Aegis Animator. Several are provided, but the addition of an entire disk of scripts for Aegis Animator and picture files for Aegis Images would improve things considerably. Perhaps more importantly, the two programs' user interfaces should be consistent to make switching between them less confusing.

CONCLUSIONS

Other than these two minor complaints, I was very pleased with this package's combination of performance and ease of use. If you want to create smooth and colorful animated video sequences on an Amiga, (for serious applications or just for fun) Aegis Animator and Aegis Images are just what you need to get the job done. ■

TURBO LIGHTNING AND STRIKE

BY ROSS RAMSEY

Two RAM-resident spelling checkers for IBM PCs and compatibles

Turbo Lightning, by Borland International, and Strike, by S & K Technology, are spelling checkers that correct your spelling as you write. Both programs are adequate spelling assistants, but each becomes less useful as your document becomes longer. When writing this review, for example, I found them to be more distracting than helpful.

If you write letters, memos, and other short notes or write notes online, you'll find either of these programs useful. For longer texts like articles and reports, you'll probably want a spelling program that lets you check an entire file at once.

At $29.95, Strike is inexpensive and allows much larger user dictionaries than Turbo Lightning. [*Editor's note: S & K Technology also sells The Resident Speller, a stand-alone spelling checker that you can buy together with Strike for $99.95. The Resident Speller uses the Strike dictionary. It has maintenance programs that let you add and delete words from your dictionary and a utility that lets you print your dictionary. It also lets you check an entire file at once.*] Turbo Lightning includes a thesaurus and has a larger starting dictionary than Strike. It also works better with other RAM-resident programs. It costs $99.95.

AUTO-PROOFING

Strike and Turbo Lightning both have auto-proof modes that beep whenever you type a word they don't recognize. These beeps catch misspellings, typos, and words that aren't in the programs' dictionaries. Turning off the auto-proofing leaves only screen-at-a-time spelling help in Turbo Lightning, and either screen or paragraph checking in Strike. Both modes are tedious for documents that are longer than two or three screens.

When checking an entire screen at a time, each program highlights the words it can't find in its dictionary. The highlighting disappears at the next keystroke in Turbo Lightning, which can be frustrating if more than one word has been misspelled. You find yourself noting the first wrong word, moving the cursor to fix it, and then requesting another screen check to find the next trouble spot.

Strike's screen checking is more convenient. The highlighted words remained highlighted in WordStar, over which I tested Strike, until I moved to a new screen. This makes the words in question easier to find and correct, and it obviates the need for constantly rechecking the screen.

Once a mistake is spotted, the procedure is basically the same with both programs. By using either a series of commands or a menu system, you can check the spelling of a word. If it's not in the dictionary, you have the option of ignoring the word, adding it to the dictionary, or looking at a list of words that are spelled similarly, from which you can choose likely substitutes for your spelling.

Both programs can be either menu- or command-driven. With Turbo Lightning's installation program, you can change the command keys to your liking; Strike's command keys are set and can't be changed.

Once the menus are on the screen, the actions for both programs are again similar: You check the word under the cursor, check the last word you misspelled, check everything on the screen (or, in Strike, everything in the current paragraph), or change the program in which you're working; for example, from WordStar to WordPerfect. The biggest difference is in the help the menus provide. Pressing F1 at any time in the Turbo Lightning menu will provide context-sensitive help. Strike does not offer as much help.

COHABITATION

One critical test is whether a new RAM-resident program will get along with already existent RAM-resident programs and with applications software. In this area, Turbo Lightning is better than Strike.

Strike has no problem running alongside SideKick until you try to check the spelling of something in SideKick's notepad. I was forced to reboot the computer each time I tried it. Using SuperKey with Strike also created problems.

I do word processing with XyWrite III, which was introduced early this year in response to complaints that older versions wouldn't easily accommodate RAM-resident programs. I used it with SideKick and Turbo Lightning with no problems. However, it would not work with Strike. Strike worked well with WordStar, one of the eight word processors on its menu of

(continued)

Ross Ramsey (716 North Madison Ave., Dallas, TX 75208) is a writer who uses computers for word crunching and finances.

Turbo Lightning version 1.00A

Type
RAM-resident spelling assistance program with thesaurus

Company
Borland International Inc.
4585 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400

Format
5¼-inch floppy disks

Computer
IBM PC, AT, XT, PCjr, or compatible; at least 128K bytes of RAM, 256K bytes preferred; two floppy disk drives or one floppy disk drive and one hard disk drive (preferred); PC-DOS or MS-DOS

Documentation
84-page user's manual; on-line help

Price
$99.95

Audience
Those with relatively small writing outputs, such as letter writers or students.

Features
The thesaurus is extremely useful if you're looking for a new word to use. The dictionary offers numerous selections to anything it sees as a misspelling. It also works well with other RAM-resident programs.

Strike version 1

Type
RAM-resident spelling assistance program

Company
S & K Technology Inc.
4610 Spotted Oak Woods
San Antonio, TX 78249
(512) 492-3384

Format
5¼-inch floppy disks

Computer
IBM PC or compatible; two floppy disk drives or one floppy disk drive and one hard disk drive; 128K bytes of RAM, 256K bytes of RAM to run other programs with it; PC-DOS or MS-DOS

Documentation
16-page user's manual

Price
Basic package: $29.95
With The Resident Speller: $99.95

Audience
Those with relatively small writing outputs, such as letter writers or students.

Features
Accommodates large user dictionaries and allows them to be added to the main dictionary.

choices. The eighth is "generic," which is worth a try if yours isn't listed.

Turbo Lightning lists 13 environments in its selection menu and allows you to build environments for programs such as XyWrite III that aren't listed. Strike offers no such tailoring. In addition, Turbo Lightning automatically changes environments as you work. If, for example, you call up SideKick while working with a word processor, it will automatically change to SideKick's environment.

DICTIONARIES

Turbo Lightning, with 83,000 words, has a bigger dictionary than Strike. Still, it beeps at you more often than Strike does. This is because Turbo Lightning's biggest RAM dictionary is 16,000 words. Sometimes it will beep because a word isn't in the RAM dictionary, only to tell you the spelling is correct after it's had a look at its larger disk-based dictionary. Turbo Lightning's manual has instructions for loading the entire dictionary into extended memory, but that wasn't possible on my 640K-byte Compaq Deskpro.

Since all of Strike's 50,000-word dictionary is loaded into RAM, it doesn't have the same problem. This is a distinct advantage if you have no hard disk drive: While Turbo Lightning ties up one drive on a floppy disk drive–based system, Strike lets you load the memory and then use your drives for other applications programs. The trade-off is that Strike offers 40 percent fewer words overall. This causes problems of its own, both in what you'll find in the dictionary and in what the dictionary will suggest to you as alternatives to whatever you've typed.

Type the word *dingbat*, for example, and Strike will tell you it's an incorrect spelling. Ask for a list of substitutes, and it comes up with absolutely nothing. This is subjective, but Strike seems less able to find similar words than Turbo Lightning, and it often finds none. The word *musicality*, it tells you, is wrong, but it makes no suggestions about what might be correct. The same is true for words like *saxophone*, *incarceration*, and *snail*.

Turbo Lightning is much better at making suggested substitutions because it goes out of its way to find words for you. All but two of the words above, *dingbat* and *musicality*, are in the Turbo Lightning dictionary, and the substitutes offered for these two words are numerous. *Dingbat* is not offered, for instance, but there are 24 suggested words available in the Turbo Lightning screens, including close words like *dingiest*, *dingoes*, *dingily*, *dingier*, and *dingles*.

Turbo Lightning is so strong at suggesting other words that it's possible to get some extra help from it. Can't spell a word? Try anyway, and then ask for similar words. Chances are that Turbo Lightning will recommend the word you wanted in the first place but couldn't spell.

Both programs let you build dictionaries of your own, and Strike is clearly stronger in this area. Where Turbo Lightning allows user dictionaries of up to 2000 characters (about 300 words), Strike lets you set the size of the user dictionary to as high as 30,000 characters (about 4600 words). This requires more memory, but when the user dictionary becomes unwieldy, a couple of utilities that come with Strike allow you to first sort your personal word list and then add it to the main dictionary in highly

compressed form. It won't add words that are already in the main dictionary, and the result is a word list that more closely resembles your own.

To try this out, I took three articles I've written in the last year and turned them over to a utility called Makeuser. Strike took the articles, removed the numbers and all the punctuation except for dashes and apostrophes, got rid of all duplicate words, and alphabetized the list. Each article contained about 2000 words, and each pass through Makeuser took only a few seconds.

Next, I took the word lists to the word processor to get rid of everything I didn't want added to the main dictionary. I then made a backup of the main dictionary and activated another utility, Dictadd. It went through the word lists and added the 115 words that were not already in the main dictionary. This increased the size of the main dictionary by 499 bytes. My copy of Strike now includes all the words mentioned above as missing from the user dictionary.

It's easy to see how powerful a dictionary you can build in a short time just using your own files. This also decreases the number of beeps you have to listen to in the future.

Turbo Lightning's main dictionary can't be altered.

It's easy to see how powerful a dictionary you can build in a short time just using your own files.

THESAURUS

One major difference in the two programs is Borland's inclusion of a thesaurus in the Turbo Lightning package. To me, this is the most useful feature of the program because I hate to stop writing to grab a reference book. The thesaurus may land me in a reference book anyway, but its convenience is valuable.

While the Turbo Lightning's dictionary can get in the way with its interruptions, the thesaurus is there only when you ask for it.

The thesaurus has 5000 keywords—words for which it has lists of synonyms. If you ask for a list while your cursor is on one of those 5000 words, a list appears right away. If you're not on one of the keywords, you get a list of words with similar spellings.

The word *cats*, for example, isn't a keyword. But Turbo Lightning offers a list of 32 other words that might be close. One of them is *cat*, and the thesaurus offers five other alternatives: *feline*, *kitten*, *puss*, *kitty*, and *pussycat*.

It's not a full-fledged thesaurus complete with definitions, but it's helpful and convenient, and I found myself looking for alternative words more often when it was on-line.

CONCLUSIONS

Strike's price and adaptability combine to make it a strong program for people who don't use other RAM-resident programs. Turbo Lightning costs more, but it offers more help to those who want more options for misspelled words and to those who want an on-line thesaurus. [*Editor's note*: *As this went to press, Borland informed us that a new version, Turbo Lightning 1.02, understands possessives, adds programs to its environment, and improves performance in floppy disk drive systems.*]

Both programs are more useful on short documents than on long ones. If most of your writing involves letters and memos, these programs are probably preferable to stand-alone spelling checkers. If most of your writing time goes into longer documents, you should consider a stand-alone program.

In sum, Strike is much better at accommodating large user dictionaries like those required in many specialties. Turbo Lightning has a thesaurus and offers more options when a word has been spelled incorrectly. It also cohabits well with other programs, including RAM-resident software. Strike has problems in this area. ■

LEADING EDGE AI BOOKS

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Handbook of Artificial Intelligence Volumes I, II, & III
Edited by Avron Barr, Edward A. Feigenbaum and Paul R. Cohen

This series is the classic introduction and reference work to the field of artificial intelligence available today. As AI continues to grow in importance, the **Handbook of Artificial Intelligence** is more relevant than ever. The volumes explain the basic theory of artificial intelligence, with basic research gathered and reworked by the editors in a clear concise manner.

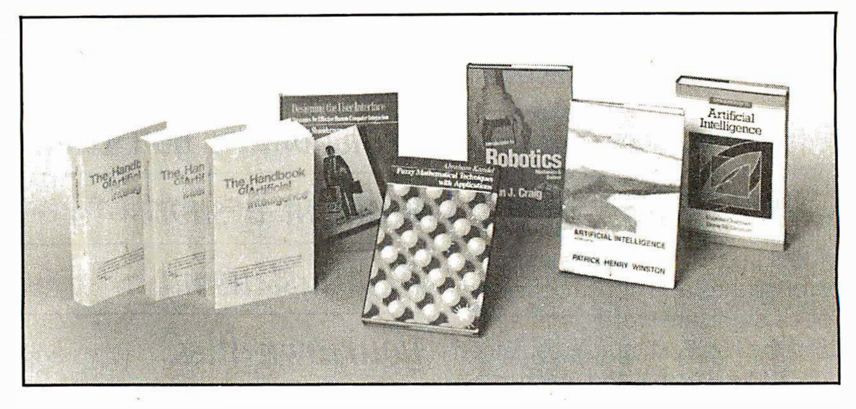
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409 pp (PB) 11811-4 (1981)

Volume II
450 pp (PB) 11813-0 (1982)

Volume III
650 pp (PB) 11815-7 (1982)

Designing the User Interface: Strategies for Effective Human-Computer Interaction
Ben Shneiderman, *University of Maryland*

A comprehensive survey of the issues in producing, managing, maintaining, promoting, training, and refining the user interface of interactive systems. The book provides an understanding of the complex interaction of people and machines. An excellent reference for those involved with interactive systems design.
304 pp (HB) 16505-8 (1986)



Fuzzy Mathematical Techniques with Applications
Abraham Kandel, *Florida State University*

This self-contained book presents the basic concepts of fuzzy set theory within a context of real-world applications. Some of the applications explained in detail are the manipulation of knowledge in expert systems, relational database structures, pattern clustering, modeling of uncertainty, and search trees.
274 pp (HB) 11752-5 (1986)

Introduction to Robotics: Mechanics and Control
John J. Craig, *Stanford University*
303 pp (HB) 10326-5 (1986)

Artificial Intelligence, Second Edition
Patrick Henry Winston, *Massachusetts Institute of Technology*
527 pp (HB) 08259-4 (1984)

Introduction to Artificial Intelligence
Eugene Charniak, *Brown University*, and Drew McDermott, *Yale University*
701 pp (HB) 11945-5 (1985)

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Programming Languages

Essential LISP
John Anderson, Albert Corbett, Brian Reiser, *all of Carnegie-Mellon University*

All the basic features of LISP are covered, as well as some applications in artificial intelligence. The book can be used with a variety of LISP dialects, but is based on the standard of Common LISP. An excellent self-study guide.

256 pp (PB) 11148-9 (1987)

Prolog Programming for Artificial Intelligence
Ivan Bratko, *E. Kardelj University J. Stefan Institute, Yugoslavia*

This book covers all the significant features of Prolog, while also providing a detailed account of artificial intelligence applications such as heuristic problem solving, symbolic manipulation, expert systems and game playing. In addition, the syntax and semantics of Prolog are fully discussed.

423 pp (PB) 14224-4 (1986)

A Prolog Primer
Jean B. Rogers, *University of Texas - Austin*

This is a thorough, pragmatic book that teaches how to program effectively in standard Prolog, via copious use of examples, problems, and solutions. Includes a thorough index and syntax summary.

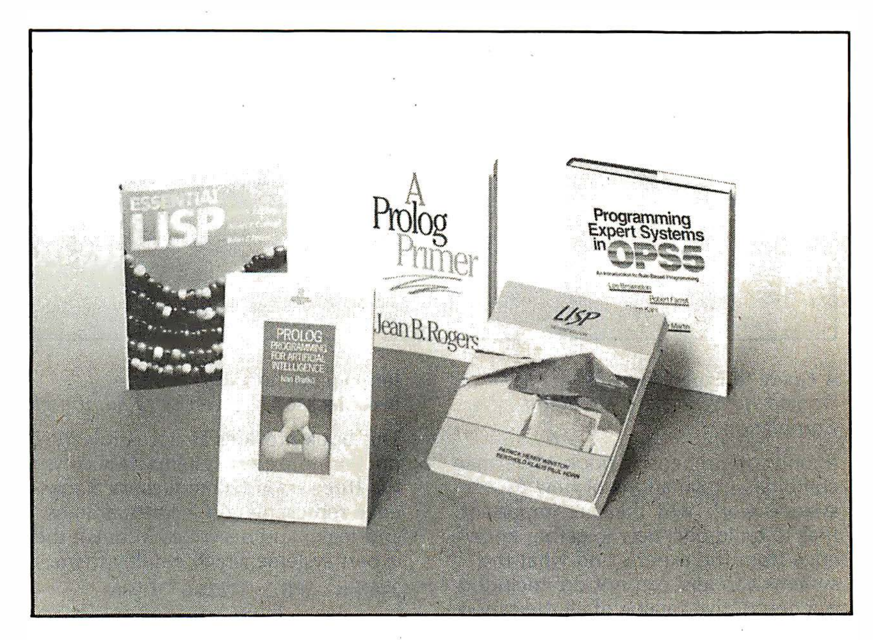
219 pp (PB) 06467-7 (1986)

LISP, Second Edition
Patrick Henry Winston and Berthold K. P. Horn, *Massachusetts Institute of Technology*

434 pp (PB) 08372-8 (1984)

Programming Expert Systems in OPS5: An Introduction to Rule-Based Programming
Lee Brownston, Robert Farrell, Elaine Kant, *Carnegie-Mellon University,* and Nancy Martin, *Wang Institute of Graduate Studies*

471 pp (HB) 10647-7 (1985)



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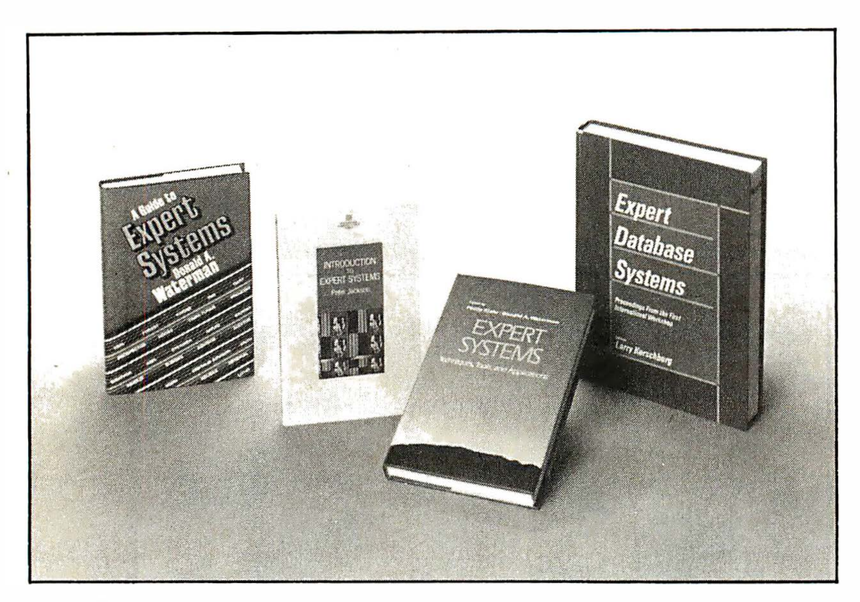
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A Guide to Expert Systems
Donald A. Waterman, *The Rand Corporation*

In one comprehensive book, Waterman combines explanations of how expert systems work, why they are important, how to build one, how to gather knowledge from the experts and what the systems can and can not do. Included is a descriptive catalog of all the expert systems you can choose from.

419 pp (HB) 08313-2 (1986)

Introduction to Expert Systems
Peter Jackson, *University of Edinburgh*

This book provides an accessible introduction to expert systems. It surveys the three main techniques for knowledge representation — rules, frames, and logic; and describes in detail the expert systems which employ them.

246 pp (PB) 14223-6 (1986)

Expert Systems: Techniques, Tools and Applications
Editors Philip Klahr and Donald A. Waterman, *The Rand Corporation*

Expert Systems is a collection of papers that describe current techniques of expert systems development, building and applications. A clear technical description of some of the most recent achievements in expert systems is provided.

441 pp (HB) 14186-8 (1986)

Expert Database Systems
Edited by Larry Kerschberg, *University of South Carolina*

An excellent reference for researchers and practitioners. **Expert Database Systems** is a unique collection of papers gathered together from the First International Workshop on Database Systems held in 1984. The book provides an understanding of the central issues and architectures of the next generation of intelligent systems.

701 pp. (HB) 33270-7 (1986)

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Software Engineering With Ada, Second Edition
Grady Booch, *Rational*

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575 pp (PB) 30604-8 (1986)

Telecommunications Networks
Mischa Schwartz, *Columbia University*

Emphasizing quantitative performance evaluation of telecommunications networks and systems, this book details the dramatic changes in the field over the past two decades.

724 pp (HB) 16423-X (1986)

Programming Pearls
Jon Bentley, *AT&T Bell Laboratories*

Bentley has compiled, expanded, and revised the best of his articles to give a deeper understanding of important programming techniques and fundamental design principles.

200 pp (PB) 10331-1 (1986)

C By Dissection
Al Kelley and Ira Pohl, *University of California, Santa Cruz*

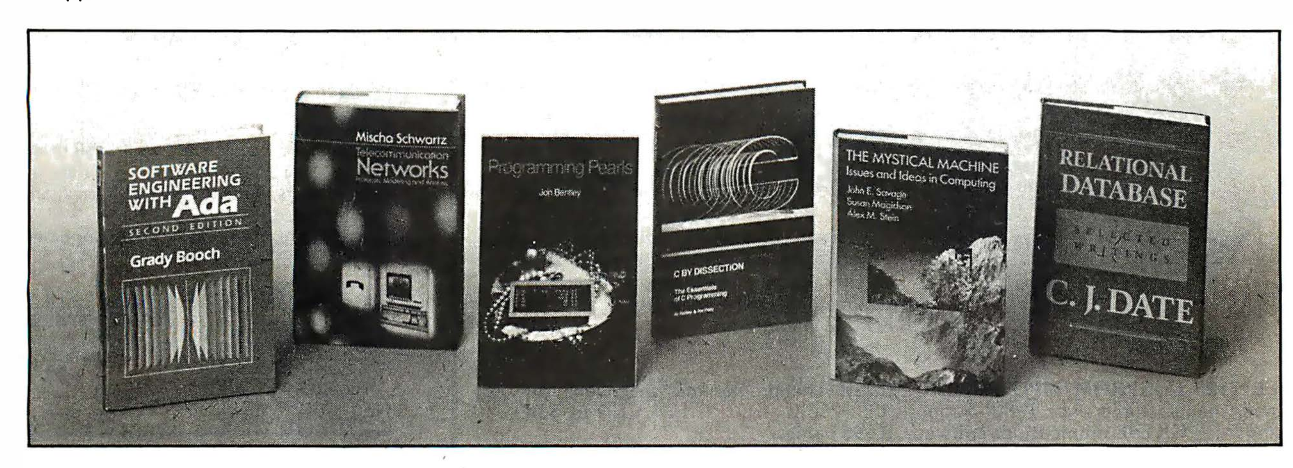
250 pp (HB) 36861-2 (1986)

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John E. Savage, Susan Magidson, and Alex M. Stein, *all of Brown University*

320 pp (HB) 06462-6 (1986)

Relational Database: Selected Writings
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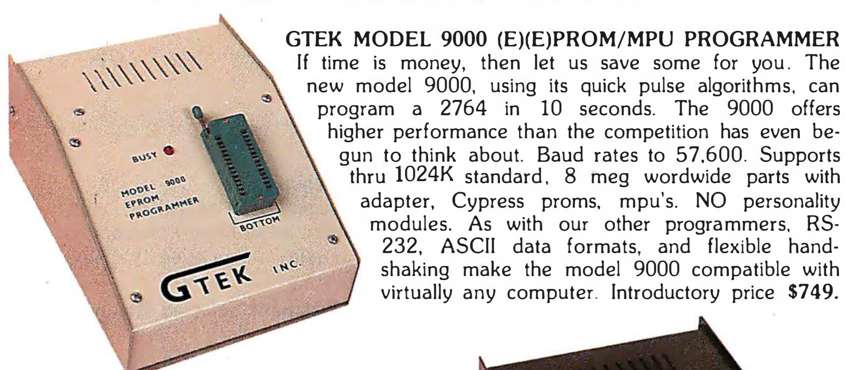
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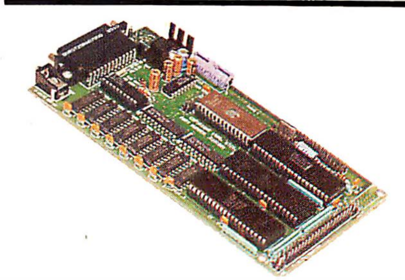
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, INC.

FILEPRO 16 AND FILEPRO 16 PLUS

BY RICHARD HARKNESS

Database management software for MS-DOS and UNIX systems

The Small Computer Company's filePro 16 and filePro 16 Plus are database management systems that run under PC-DOS and MS-DOS and, in their multiuser versions, UNIX and XENIX. Other versions are available for several machines that are not strictly IBM PC–compatible.

Both programs are written in a combination of C and assembly language and are very fast, especially in the key operations expected of relational database management systems: sorting, selecting, and processing large groups of records (see the benchmark results in table 1). A hard disk is required, except with the Tandy 2000. With this machine's extra floppy disk capacity, it can, with a bit of disk-swapping, handle filePro 16 but not filePro 16 Plus.

The first version of filePro 16 was a highly popular database manager called Profile, a program for Radio Shack's line of 8-bit TRS-80 computers. It evolved and moved to the MS-DOS environment, picking up a new name, Profile 16, along with its enhanced capabilities. Profile 16 (designed for Tandy's Model 16 and 6000 machines) and filePro 16 are virtually identical.

FILEPRO 16 VS. FILEPRO 16 PLUS

Conceptually, filePro 16 Plus, which has more applications development tools, is geared toward software applications developers, while filePro 16 is well suited for end users who want to set up and manage a database. Optional transfer utilities port applications between operating systems (such as transferring files between single-user and multiuser systems), convert external data files to filePro 16 format, and transfer filePro 16 files to other formats such as DIF, SYLK, and ASCII.

The filePro 16 Plus program has a built-in feature that can treat external files as filePro 16 files. Both programs actually consist of two major building blocks: The first block is a sophisticated file manager, and the second block is a powerful programmable file processor. Many users may never need anything but the first block.

CAPACITIES

With filePro 16 you can have as many files as you have hard disk space, with up to 16 million records per file; 999 fields, 4608 characters, and 36 screens per record; and 200 processing elements per table. The filePro 16 Plus program provides 16,384 characters per record and 1000 processing elements per table.

CREATING A FILE

Operations in filePro 16 are menu-driven with a generous number of prompts throughout the program. To set up a file, you type the name you want it to have and, on a table provided, fill in a list of fields and lengths for each record. If you desire, the program will make a screen, a report format, and an index for you. You can build on this format as your needs grow.

You can make any modifications you want before adding data to a file. After adding data, you can add new fields only at the end of the existing fields. This prevents confusion of field numbers. If your records are lengthy, it's a good idea to always make a few reserved fields in the key segment: Simply type in a field number but set the length to zero. Information in the key segment is processed faster than information in the data segment, so it's desirable to put the most frequently sorted and selected fields in the key segment.

FIELD TYPES

As you define fields, you can specify an edit type for each field. By specifying the Phone edit, for example, the field will accept only numbers and will change an input of 1112223333 into (111) 222-3333 automatically. There are also date, time, and numeric edits to ease input and ensure data integrity. You can even customize your own edits.

CREATING INPUT SCREENS

Creating screens for data input with filePro 16 is a pleasure because it's done directly—you see exactly what you're getting at every step. Reverse video, simple line graphics characters, and automatic box drawing make drafting professional-looking screens easy.

You can use several useful system-maintained fields, which can be sorted and selected just like other

(continued)

Richard Harkness (1224 King Henry Dr., Ocean Springs, MS 39564) is a consultant pharmacist and a writer.

filePro 16 and filePro 16 Plus

Type
Relational database management systems

Company
The Small Computer Company Inc.
41 Saw Mill River Rd.
Hawthorne, NY 10532
(914) 769-3160

Format
filePro 16: five 5¼-inch disks;
filePro 16 Plus: six 5¼-inch disks;
no copy protection

Computer
Single user: IBM PC, XT or AT; filePro 16: 384K bytes of RAM; filePro 16 Plus: 512K bytes of RAM; multiuser (XENIX or UNIX): IBM PC AT compatibles; AT&T Model 3B2 and Model 7300; Fortune 32:16XP; NCR Tower; Plexus computers; Tandy Model 16 and 6000

Documentation
Reference manual; tutorial manual; quick reference guide; installation manual

Price
filePro 16 for single user: $495; filePro 16 Plus for single user: $990; run-time versions available; single-user upgrade from filePro 16 to filePro 16 Plus: $495; multiuser version prices vary according to computer and operating system

Audience
End users and applications developers

fields. Typing in @UD, for example, instructs the program to input automatically the date on which a particular record was last updated. Suppose you have several screens per record and a few common fields on each screen, one of which is a client's name. Entering the client's name on the first screen causes it to be automatically filled in on all the other screens. The protected field indicator, an exclamation point, can be used on all secondary screens to assure that this field cannot be altered except from the first screen. Using the must-fill indicator, a percent sign, makes sure critical data is typed in before the record can be entered. You can set a cursor path that takes the operator through the fields in a specified order.

OUTPUT FORMATS

Creating output formats for printing is similar to creating screens. You put the fields on a video form to indicate where you want them to appear on the printed form. The filePro 16 program lets you create formats for reports, labels, full-page forms (which can be tailored to match insurance, paycheck, and invoice paper forms), and free-form documents. You can also define processing-only formats for batch operations. You can set your sort choices as part of the format or decide on them later. Now you are ready to create empty records and fill them in. Password protection is optional.

INDEXES

You use the Index Maintenance mode to build indexes, which can be one of two types: automatic or demand. Automatic indexes are maintained by the program, adjusting themselves dynamically as you add, delete, and change records. You might use an automatic index to keep your records in alphabetical order by client name, for instance. Any record is almost instantly available by typing in the first few letters of a client's name. Demand indexes, which have complex sorting and selection capabilities, can be used for inquiry and printing operations. You can base one index on another to narrow selections. There are eight sort levels. Sorts can be ascending or descending on numeric, time, date, and text fields.

SELECTION CAPABILITIES

The filePro 16 program's selection capabilities are impressive. Even a very imaginative user would be hard-pressed to find a need to release their full potential. You can select records by up to 72 criteria at a time. An extended selection table contains twelve lines for defining selection criteria. You can give the filled-in selection lines a name and save them as sets for regular use. Group labels relate the lines to each other by AND, OR, or the relationship codes. These codes include EQ, NE, GE, GT, LE, RG (for selecting ranges), CO (which means *contains*), and xxF (for comparing fields to themselves using a relationship code). At the bottom of a selection table is a selector sentence. Labeled selection lines can be further related to each other, or to other saved selection sets, in the selector sentence using AND, OR, and NOT. Previously saved selection sets can also be used in processing tables.

THE PROCESSING BLOCK

Processing is the block that creates complex interactive applications such as a full-featured accounting system. Similar to BASIC programming, processing uses IF and THEN elements and relationship codes. Three types of processing are available: input, automatic, and output, which is done during batch runs. You program commands into a processing table. There are 19 commands, including AVG, COPY, DELETE, END, GOSUB... RETURN, GOTO, TOT, and LOOKUP,

Table 1: *These benchmarks were performed on a database of 1000 records of 100 characters each. Times to perform each function are rounded off to the nearest second.*

Sort file on nonindexed field: 26

Access the last record in a nonindexed file: 22

Access the last record in an indexed file: instantaneous

Index a file: 64

which temporarily connects different files.

UNIQUE FEATURES

The filePro 16 program has several unique features. At the bottom of each screen within a record appears the message "F-Print Form." Pressing the F key and typing in the name of one of your output formats, such as a report, invoice, or envelope, immediately prints the specified form for that particular record. This is a handy feature that shouldn't be undervalued. Most other database managers can do this operation only through a batch process. User-defined menus automate any combination of functions. Pressing one key on such a menu causes the program to go through an unseen but complicated ritual of predefined sequential keystrokes.

One of my favorite features is called Associated Fields. You can relate several different fields by using a special code in Define Files mode. When you type this code instead of a particular field number, the program does a specified sort or selection on all the related fields during a single run.

For instance, as a consultant pharmacist, I set up a database of drugs, with one drug per record. I wanted to input information on adverse side effects for each drug. Here's a simplified verson of what my associated fields looked like when I created them in Define Files mode.

Field
1—Drug name
2—A1) Adverse side effect
3—A1) Adverse side effect
4—A1) Adverse side effect
5—A1) Adverse side effect

I could now input four of the most common side effects for each particular drug. There might be several hundred drugs on file.

Suppose I needed to know all the drugs that had *dizziness* and *drowsiness* as side effects. Selecting on field A1 causes the program to search fields 2, 3, 4, and 5, calling up the records that have both *dizziness* and *drowsiness* listed in their side-effects fields.

Consider what would have to be done using a conventional system: I would have to do a search through each of the four fields separately for *dizziness* and then do the same thing for *drowsiness*. Afterward, I'd have to manually search through all the records selected and eliminate those that didn't have both *dizziness* and *drowsiness* listed.

filePro 16 Plus has many added features that are valuable for applications developers.

IMPROVEMENTS

Earlier versions of filePro 16 had a few gremlins: The file directory function did not display selection sets, processing types, and output formats; the program would occasionally hang up in Index Maintenance mode and require a warm reboot; and, over a length of time, the automatic indexes faltered in keeping records in the specified order. So far, with the latest version, I have not encountered any of these prior problems.

The filePro 16 Plus program has many added features that are especially valuable for applications developers. These features include customized help screens, a debugger for processing, increased speed due to precompiling of processing tables, 31 additional commands and functions for processing, more extensive error checking for processing functions, three more system-maintained fields, 12 additional user-menu command-line instructions, enhancements to the output functions, and filename qualifiers, which allow the use of the same file structure, screens, or reports for other files.

CONCLUSION

The filePro 16 and filePro 16 Plus programs are among the best of the microcomputer database management systems. They adequately fill the needs of end users and software developers and certainly deserve consideration. ■



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XEROX 6060

In the review of the Xerox 6060 (September BYTE), Wayne Rash Jr. stated that third-party monitors might be difficult to use with this machine. As you know, the Xerox 6060, the AT&T PC 6300, and the Olivetti M24 are similar machines. Therefore, any monitor that works with a PC 6300 will also work on an M24 and a 6060.

I went to an AT&T dealer to buy a color monitor for my PC 6300. They wanted $945 for a 640 by 400-pixel color monitor. I thought this was expensive when similar third-party monitors for IBM clones were selling for half that price. I really wanted the NEC MultiSync monitor, but I was told by NEC and AT&T that it would not interface properly with my PC 6300.

Talking about this with a colleague, I was referred to a company in Fairfax, Virginia, that sells cables that allow third-party monitors to interface with an AT&T PC 6300.

I am happy to report that I bought both the NEC MultiSync monitor ($510) and a cable ($65) for a total cost of $575, and it works great. For people who own an AT&T PC 6300, an Olivetti M24, or a Xerox 6060, there is an alternative.

MICHAEL RICCIARDI
Fairfax, VA

LEADING EDGE MODEL D PC

I was glad to see the review of the Leading Edge Model D PC (September). The Model D is a fine machine that deserves attention as an IBM PC or PC XT alternative. I work with Model Ds on a daily basis, and I am impressed by them.

Stan Miastkowski's article is already a bit dated. The Leading Edge Model D PC now comes with 512K bytes standard, upgradable to 768K on the motherboard. Of course, only 640K is available in main memory, but the extra 128K would do fine for a RAM disk.

You can now get the base unit with twin floppy disks for $1295. For $1495, you get not only the Leading Edge Word Processor, but the Twin Lotus 1-2-3 clone and a Leading Edge 300/1200-baud internal modem as well. A 30-megabyte hard disk model is now available for $1995.

I have found the Model D to be very reliable. Leading Edge had a bit of trouble with the CMI hard disks it previously used, but it quickly switched to Seagate hard disks, unlike IBM, who took more than a year to even acknowledge a problem with the hard disks in the PC AT. You can perk the Model D up with NEC's V20 chip. If you want more speed out of the unit, the only speedup card I have found that claims compatibility with the Model D is PC Technologies' 286 Express Card. Orchid Technology's and Mountain Computer's boards will work, but you have to disable caching, which defeats the speedup to a large extent.

We have two Model Ds on G/Net with a TeleVideo TeleCAT server, and they perform flawlessly. Worth noting is the 720- by 400-pixel monochrome graphics, ideal for an inexpensive CAD workstation (yes, it runs AutoCAD).

Quite simply, the Model D gives you more for the money.

JIM PALMER
Clarksville, TN

TURBO PROLOG

Readers familiar with the operation of Intel's 8087 numeric coprocessor may very well be astonished by Namir Clement Shammas's comment in his review of Turbo Prolog (September). He states that the benchmark tests, "by virtue of their speed, seem to automatically use the 8087 coprocessor, although the Turbo Prolog manual does not mention 8087 chip support."

First, the speeds in the table are not especially fast, even for a compiler without 8087 support. I have found Turbo Prolog's speed to be somewhat slower than that of Microsoft's Quick BASIC 2.0 (which has double precision and no 8087 support) when tested with the well-known Savage benchmark (see "The 8087/80287 Performance Curve" by Stephen R. Fried in BYTE's *Inside the* IBM PCs, Fall 1985). However, the speed is not terrible, either; in benchmarks that use transcendental functions, Turbo Prolog is significantly better than Turbo Pascal version 2.0, but a little slower than version 3.0 (both with 6-byte real numbers and without 8087 support).

Second, I found no FINIT, FSCALE, FPTAN, or FPATAN instructions when searching the code compiled from the author's test programs, which were downloaded via BYTEnet Listings, or the compiled Prolog version of the Savage benchmark. You can easily find all these instructions when searching code compiled for the 8087 FORTRAN version of the Savage benchmark, however. The instructions above (with the possible exception of FSCALE) would be necessary in any program that evaluates arctangent, sine, or tangent using the 8087.

Third, it is generally true that for desirable features like 8087 support, if it isn't in the manual, it isn't supported.

DAVID R. CLARK
Garland, TX

FIVE LABORATORY INTERFACING PACKAGES

The July review entitled "Five Laboratory Interfacing Packages" by Patricia Wirth and Lincoln E. Ford was excellent. This article was very timely, since the company I work for is currently evaluating three laboratory packages. I was very surprised to see that the RS/I package by BBN Software Products Corp. (Cambridge, MA) was not reviewed.

RS/I was originally designed for the DEC VAX and PDP-11 systems, but it is now available for the IBM PC XT and PC AT. The $2000 package includes spreadsheet tables, simulation of models, graphics, a command language, digital I/O sampling, example-based documentation, data manipulation (including sort/merge, curve fitting, and text editing), DOS file I/O, statistics, macro procedures, an RPL programming language with debugger, and call routines created by other compilers (FORTRAN and Pascal).

Please pass this information on to your readers. Anyone looking at laboratory packages should consider RS/I package.

KURT MARLEY
Scottsdale, AZ ■

REVIEW FEEDBACK *is a column of readers' letters. We welcome responses that support or challenge* BYTE *reviews. Send letters to Review Feedback,* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458. *Name and address must be on all letters.*

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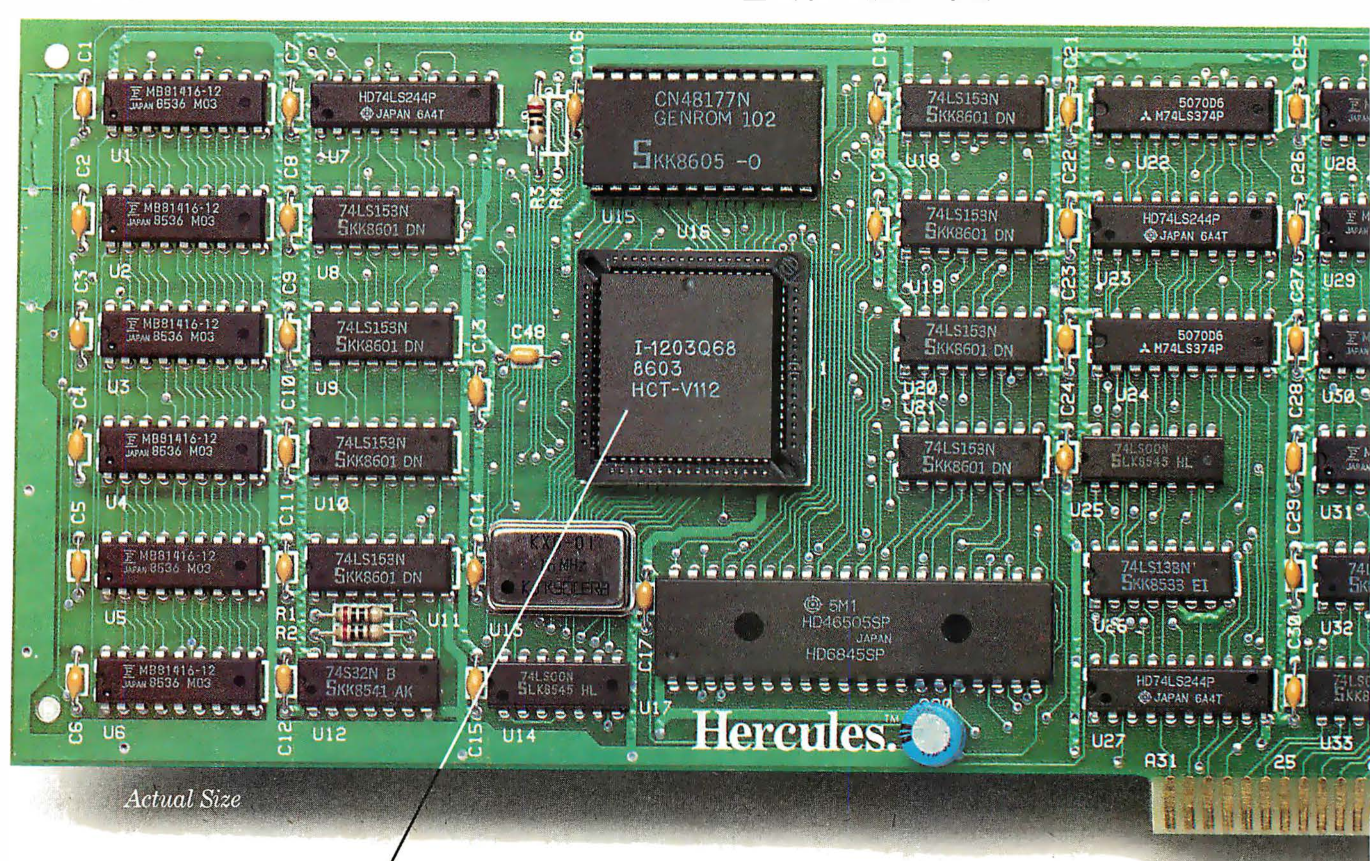
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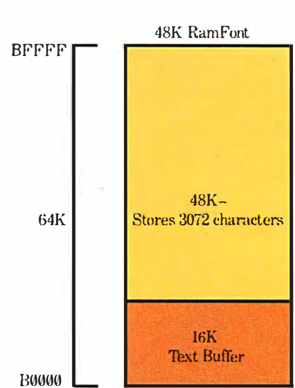
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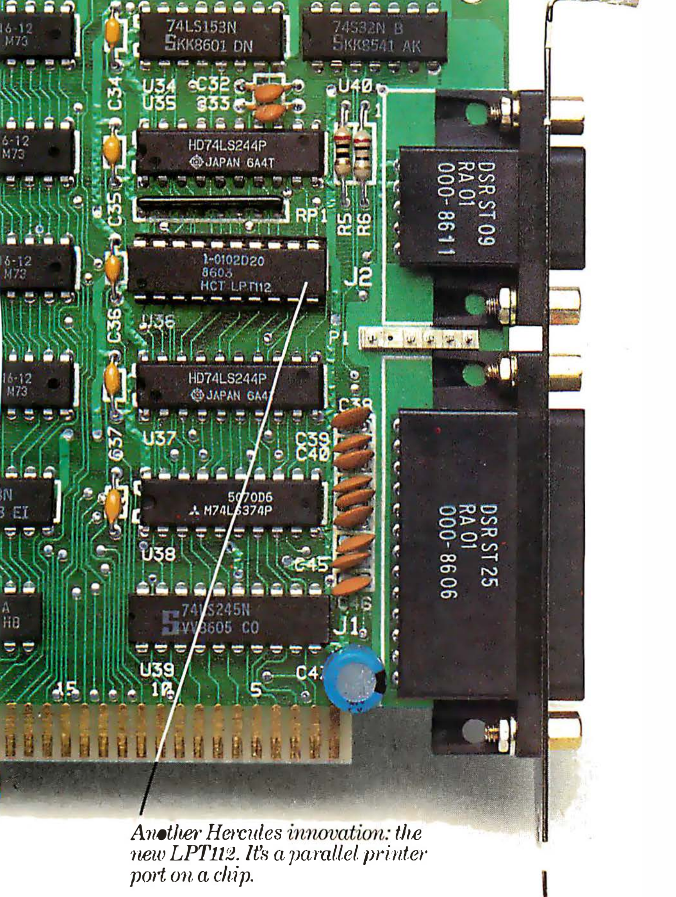
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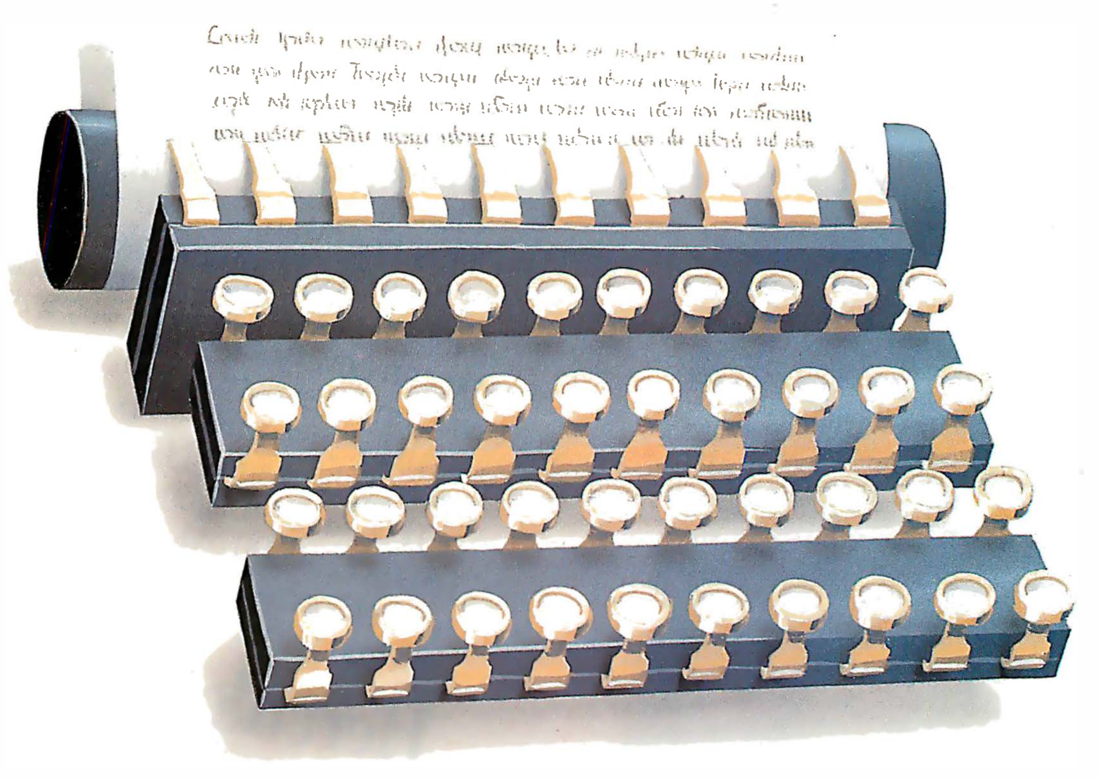
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Kernel

THE IMPORTANT MISSION for Jerry Pournelle this month was finishing up the report of the Sixth Meeting of the Citizens Advisory Council on National Space Policy. But computers were important here. Jerry says it couldn't have been done without BIX. Even though the report took up much of his time, he was able to do some playing around with computers. The area of particular interest this month was graphics, as Jerry installed EGA boards in Big Kat. He also looked at some new products, including the Tandy Model 200 and Reflex.

Some of you may have thought a knockout occurred in Round 2 of the 68000 wars in last May's According to Webster. Since the intervening months have seen a dearth of action, you logically might have assumed that the bout had ended. But the contest resumes this month with Round 3. Bruce's special focus this time is a comparison of four flavors of the Macintosh. Bruce also discusses Megamax C for the ST, HiSoft's DevpacST, Metascope for the Amiga, TxEd, and Turbo Pascal for the Macintosh.

In his concluding column for us, Bill Raike looks at some recent developments in Japanese computer technology. First, he discovers that vending machines are now offering on-line information. He then looks at a new computer from NEC, the PC-9801VM2E. This model, meant for the U.S. market, will allow its users to do Japanese-language word processing. Bill closes the column by describing the first Japanese-language BBS he has seen.

The subject of BYTE U.K. is wafer-scale integration of semiconductor devices. In this process, the whole wafer is used with the chips connected on the silicon. The leader in WSI research is Ivor Catt, a veteran of British electronics. Catt is now part of a company called Anamartic, which was formed to pursue and market WSI devices. The first commercial product incorporating this technology is now scheduled to appear in late 1987.

Ezra Shapiro looks at some memory-resident programs in Applications Only. Ezra begins with a cautionary message about this type of program. As a class, they cause as many problems as they attempt to solve. In fact, he has discovered that the more of them you use, the more likely you are to freeze your software, crash your system, or lose your data. He then looks at four such programs. His favorite is Cruise Control. Ezra closes the column by considering Works for the Macintosh.

Wow! We have a money-making article in the Kernel section this month. Watch out, *Fortune*. In his Mathematical Recreations column, Bob Kurosaka looks at some classic sucker bets and how they work. Even if you don't win any money, you will learn something about probability.

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A Graphic Display

BY JERRY POURNELLE

Jerry and Alex put enhanced graphics adapter boards in Big Kat

Well, it's done. The report of the Sixth Meeting of the Citizens Advisory Council on National Space Policy is finished. G. Harry Stine is polishing up additional materials to make it into a book—*America, A Spacefaring Nation Again* (Baen Books, Jerry Pournelle, G. Harry Stine, and Barbara J. Clifford, editors)—but the report is finished.

It simply couldn't have been done without BIX. Previous Council meeting reports have been influential, but they were largely confined to the results of the meetings themselves; and the meetings were all too brief. This one is different because it is as if the meeting went on for several weeks. We're just learning how to use electronic conferencing, but the results are already spectacular.

There is still much to learn. In particular, BIX needs more sophisticated indexing and retrieval features. All too often I had to search through big conferences loaded with chatter and irrelevancies in order to find the key document I needed. There needs to be a way to mark messages as "important" so that you can search only those. We also need ways for the conference moderator to take out a document, change it, and put it back in, leaving in its place a pointer to the update's location.

For many subscribers, BIX's main value is the amazing variety of easily available technical information: it's hard to think of a question that one or another of the BIX users can't answer. But I'm interested in developing the conferencing aspect. Probably the most intensive learning experiences of my life were graduate seminars; I don't see why something of the sort can't be put together electronically.

I'm convinced that computer conferencing will change our whole way of thinking about education.

EGA

The Council report came first, but we did manage to do some playing around. For one thing, my son Alex and I installed enhanced graphics adapter (EGA) boards in Big Kat, the Kaypro 286i AT clone.

Big Kat normally runs off a Hercules Color Card that is IBM Color Graphics Adapter (CGA)-compatible and plays into a 17-inch Zenith High Resolution Video Component System color monitor. By flipping a couple of switches, I can also make that monitor show me cable TV or the output of a VCR.

Big Kat ends up doing much of the computer work here. He's the test station for most MS-DOS software. He runs SuperCalc3 to do my expense reports. SideKick is installed, and I use that to keep my phone list, address book, and calendar and then print them all out with Traveling SideKick when I'm going on a trip. Most important, I suppose, is that Big Kat is set up as my main station for connecting to BIX, what with SuperKey BIX macros and all.

The Hercules/Zenith setup is good enough for all that, and for most games as well. What it isn't good enough for is writing. If I had to stare at those fuzzy letters for hours on end, I'd go out of my mind. Thus, when both Orchid Technology and Paradise Systems sent EGA boards, I was ready for the change.

I confess a certain fondness for Orchid. Their boards work—at least all the ones I've had here do—and installation has generally been painless. Actually, that isn't always true. Sometimes what happens is that Orchid sends me something; I try to get it to work; I call them and tell them my problems; and they change their documents and installation instructions. The result is that it's reasonably painless for my *readers*.

The Orchid EGA documents are clear enough and promised no difficulty. The Orchid EGA comes with a pair of little programs; you run the appropriate one to tell the board whether to be EGA or CGA. However, the Paradise board offered a more interesting feature, automatic switching between EGA and CGA. The board is supposed to figure it out for itself. That looked like a good idea. Also, the Paradise board is half-size; not that I'm short of full slots, but waste not, want not.

Installing the Paradise board—its formal name is AutoSwitch EGA Card—was simple enough. When we turned on Big Kat, he complained that something wasn't properly set up, and we had to boot with the F1 key. Everything then seemed to work fine. SideKick, SuperKey, the Logitech Logimouse software, and Ready! all came up, and all worked. We ran the Setup program that came with Big Kat, but when we tried to reboot we got the setup error again. I think we never did figure out what the machine was complaining about, since everything worked fine.

(continued)

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future.

The Paradise board in CGA mode performs as advertised. The scrolling is flicker-free, just as they say. Text on the Zenith screen looked sharper and crisper to me; that may be an illusion, as I had no way to make direct comparisons. Games looked good, too.

Enter EGA

It was then time to try something in EGA mode. We selected RIX Softwork's EGA Paint for the test. This is a good standard color paint program with some extra features. What made us choose it is the clear and simple documentation. It looked as if it wouldn't take much to get it running.

There was only one problem. EGA Paint needs 384K bytes of available system memory.

Alas, even though I begin with 655,360 bytes of total memory, what with all the memory-resident programs I run, I don't *have* 384K bytes of available system memory. Now true, that's my fault. I have four different boards here that are supposed to let me put some of my memory-resident stuff in extended or expanded memory—that is, memory over and above the 640K bytes that DOS recognizes. My problem is that except for very brief tests I haven't installed one of them and got used to it.

Rather than install a new board and thus complicate things, we renamed the AUTOEXEC.BAT file that brings in SideKick, Ready!, and the other stuff and rebooted. Then we brought in EGA Paint.

The result was as expected. The Zenith screen went mad. The EGA board uses different sweep frequencies than the CGA-compatible Zenith. In general, you can't use the same monitor for EGA and CGA.

Fortunately, there are exceptions to that rule. Time, then, to bring in the NEC MultiSync color monitor.

NEC MultiSync

Installing the NEC MultiSync turned out to be the simplest thing in the world. The Zenith was still displaying rapidly moving garbage. We disconnected it and plugged in the NEC. The NEC itself had been running off the CompuPro PC Video board. The PC Video board is an S-100 board that emulates the IBM PC CGA, except that it's considerably sharper and doesn't flash when it scrolls; it's what allows CompuPro machines running Concurrent DOS to run a number of MS-DOS programs, including Lotus 1-2-3.

Anyway, we unplugged the NEC MultiSync from the CompuPro and plugged it into the Kaypro. Presto: an absolutely gorgeous picture came up on the screen.

We spent the next hour looking at some of the art provided in the RIX Softworks EGA Paint package and testing the Logimouse. Everything worked fine. Colors were really nice. Text embedded in the EGA Paint pictures looked good.

The next thing was to try a text editor with an EGA mode. I won't say

(continued)

which one we used, because it wasn't a fair test; all I wanted was to get a couple of screens full of text and see what it looked like.

It looked fine. The NEC MultiSync isn't a perfect monitor. It's a matter of taste, of course, but it's too small for me. Worse, it has a tendency to pincushion with text—the edges of the screen bow inward like this)(. Even so, it's good enough. I could write books with the Paradise AutoSwitch EGA Card and NEC MultiSync monitor, provided, of course, that I had a good enough text editor.

We did a few more tests. The NEC monitor has a couple of little switches on top. One puts it in a "text mode"; that doesn't make much difference when it's doing EGA, but when it's doing CGA text, you definitely want to flip that switch.

The Paradise board has a little trouble when you're running an EGA program and flip into SideKick. SideKick is, of course, CGA-compatible. When it pops into an EGA program it confuses the Paradise board, and there are blinks and glitches before it settles down. All's well after that.

Alas, there was one insurmountable problem.

The Hercules Color Card has a parallel printer port on it. The Paradise AutoSwitch EGA Card doesn't. I use Big Kat's parallel printer port to connect to the HP LaserJet Plus (well, actually to Applied Creative Technology's Printer Optimizer, but it attaches to the LaserJet Plus). I can't live without a printer attached to Big Kat. I have a couple of boards that do have parallel ports on them, but it was just too late to install something new. Reluctantly, we put things back the way they were.

There's another problem. The MultiSync monitor really is too small. The screen is somewhat larger, but I measure no more than 11 inches diagonally in the actual video display area. Text in EGA mode is sharp enough that I *could* sit far enough away to see it without using the reading lenses in my bifocals, but it would be a strain.

Incidentally, whenever I write about eye comfort I am sure to get several letters suggesting that I get bifocals

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ONE BETTER

Inquiry 48

What I want is a high-res color monitor, like the MultiSync, but 14 to 18 inches in size.

with the reading elements on top, or just get reading glasses and have done with it. I thank all of you for your concern. The fact is, though, that I've tried reading glasses, and it doesn't work. If I sat at the keyboard and did nothing else all day it would be different, but I can't and don't do that. I'm perpetually getting up to find a book or a magazine, or find my notes, or just to go out onto the balcony and water the plants. I've never got in the habit of keeping track of spectacles: if they're not on my nose, I'll never find them. If I had to change from reading lenses to regular bifocals, I'd probably lose both sets and be completely out of business.

What I really want is a high-resolution color monitor that works like the MultiSync but is between 14 and 18 inches in size. So far as I know there aren't any of those, but surely it's only a question of time.

I'm convinced that EGA will be the new business standard in a couple of years. If you're looking for a new monitor, you don't want to lock yourself into the older low-resolution mode. On the other hand, there's still a fair amount of essential software out there that runs only CGA, so you need something that can handle that. The NEC MultiSync makes a lot of sense.

More Paradise

Paradise has two other short-slot boards that I could use. Both have parallel printer ports on them. One, the Color/Mono Card, is jumper-selectable (not automatic) to operate as either monochrome or CGA. The other, the Hi-Res Graphics Card, is said to "give you the highest resolution possible with standard monitors and popular off-the-shelf software" with flicker-free scrolling. With this board, the setups are done by using switches rather than jumpers.

Installing the Hi-Res Graphics Card is as simple as installing any other card. The instructions are clear to the point of simplemindedness. I had no difficulty even late at night.

New brooms sweep clean. When I first installed it, I had the impression that the text on the Zenith 17-inch monitor was a bit sharper and brighter than it was with the Hercules board, but I certainly wouldn't want to bet on it. By next morning I was convinced otherwise; see below.

The parallel printer port works fine. When I first booted up, that wasn't necessarily the case. My first test was to print the screen; that seemed to work all right, but of course the Print Screen button doesn't send a formfeed, and the LaserJet doesn't print anything until it has either a full page or a formfeed. I have a file, HPINIT.BAT, that tells the LaserJet that paper is 66 lines long. It does that by "printing" an elaborate escape sequence, and incidentally sends a formfeed to the printer. When I did HPINIT I got what seemed a standard reply, but then the machine locked up, and I mean really locked up: it didn't even hear Ctrl-Alt-Del. I had to turn the power off.

When I turned it back on, everything worked. I've "printed" my HPINIT file six times, done screen dumps, printed files, and generally tested that printer port; no problems. I can't imagine what happened the first time.

I left the Paradise Hi-Res Graphics Card in Big Kat overnight with the system turned on. In the morning, all the text had moved over so far to the left that part of the first character on each line was gone. There's no horizontal hold adjustment on the monitor—notice how they've automated everything lately, and how inconvenient that is? Also, the letters seem fuzzy, much worse than with the older Hercules Color Card. I'm going back to the Hercules board.

It's always dangerous to generalize from a sample of one. The other Paradise board worked fine. Probably this board is out of adjustment. I tried to call Paradise, but after 11 rings I got

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I'm carrying both the Tandy 200 and the NEC PC-8201 *on trips while I make up my mind.*

"Paradise hold please," and after five more minutes on hold long distance I said to heck with it. There don't seem to be horizontal controls on the board, so it's unlikely they could do anything except replace it anyway.

THE GREAT TANDY ANNOUNCEMENT

In the early days of the micro revolution, I developed considerable prejudice against Radio Shack. It wasn't unreasonable, being based on a number of experiences; but it's long past time I dropped it. Radio Shack has changed. In particular, they have completely revamped the quality control practices that distressed me. Tandy always had the potential to be a major player in the micro revolution. I think now the company is moving in the right direction.

In early July Tandy announced that on July 30 they'd make a *big* announcement at the Waldorf in New York. For weeks the micro press corps was abuzz with rumors, ranging from "they're going joint venture with AT&T" to "the mountain labors, and produces a mouse."

It wasn't a joint venture with AT&T, but it wasn't a mouse either. They announced five new machines. Radio Shack moved into the micro field in force, with machines to challenge Atari and Commodore on the low end and direct confrontation with IBM PC AT clones at the high end.

At the very low end is the Color Computer 3, which I suspect they're keeping in anticipation of big things happening on the CD-I (compact disk-interactive) front. CD-I, you may recall, is the next step after CD-ROM disk systems. It will be a disk reader that can double as a compact digital disk audio player. In addition, it will contain a 68000 microprocessor and be able to execute instructions from the CD-I disk it is reading.

The OS-9 operating system is built into the CD-I standard; the Color Computer 3 uses OS-9. At $219, the CoCo 3 is positioned nicely to become a standard monitor for CD-I systems when those become available.

As for their other machines, which range from what looks like a PCjr, only done right, to a full AT clone, we'll have to wait and see. The prices seem a bit high, but price isn't everything.

By the way, it's interesting to see that they've done another change of emphasis. For the past couple of years, the Tandy exhibits at shows have tried to hide any association with Radio Shack. This announcement was by Radio Shack, a Division of Tandy, and proud of it. That's another good move.

TANDY 200

The Tandy 200 came out during the "suppress Radio Shack" phase, I guess, since there's no TRS on it anywhere. (Could they be trying to get rid of TRS because everyone pronounces it "trash"?) There's no mention of "Radio Shack," either, except that in fine print the warranty says that "Radio Shack grants to customer" a license to "use the Tandy software. . ."

Anyway, the Tandy 200 is a lapboard. It has some similarities to the TRS-80 Model 100. The chief difference is that there are 16 lines instead of the 8 on the Model 100 or the NEC PC-8201 screen. You pay for this in weight (although the increase isn't all that significant) and convenience; the Model 200 has a flip-up screen, which makes it significantly harder to balance on your lap in an airplane. On the other hand, it's easier to use if you have a table at the right height.

Sixteen screen lines aren't enough, but one can live with it. After all, I write these columns and all my books on a 16-line CompuPro S-100 system that runs an ancient VDM memory-map video board. Alas, the Model 200 has only 40 characters per line. This keeps things readable—the Model 200 is perhaps not quite as readable as the Model 100 or the NEC, but the difference isn't much—but it also makes writing harder.

There's another difference from the Model 100. The Model 200 has much nicer cursor arrow keys, reminiscent of the NEC PC-8201. Like the Model 100, the Model 200 has a built-in 300-baud modem. Other features include Multiplan in ROM and the built-in ability to add three banks of 24K-byte memory.

That really isn't enough memory for a long trip. One of the things I like a *lot* about my NEC PC-8201 is the external memory connector port. I especially like Purple Computing's Sidecar bank memory system: it gives me four banks of 30K bytes each, which is enough for a long trip. On the other hand, Traveling Software's Ultimate ROM II for the Model 200 has both LAPDOS and TS-DOS, meaning that you can connect a 3½-inch disk drive to the Model 200 and save your text on that. Since it's extremely unlikely that I'll ever do enough work on an airplane to use up the Model 200's 60K bytes or so of on-board memory, I could live with the memory limits; just carry a portable small disk drive in checked luggage and save at the hotel.

I'm not sure I can live with the 40-character lines. Unfortunately, the Model 200 has a different system for writing to screen than the Model 100 uses, which means that Traveling's Ultimate ROM II for the Model 200 does *not* have the 60 characters/line capability it gives you in the Model 100 or the NEC PC-8201.

As a result, I'm carrying both the Tandy 200 and the NEC PC-8201 on trips while I make up my mind. It makes me look like a nerd, but it does give me a chance to test the two machines.

I do find lapboard machines increasingly useful. Some of my readers report that they carry their lapboard machines literally everywhere, to appointments, in their cars, even to lunch. Some never use any other kind of machine, not by necessity but by choice. I can see why. Any of these would be better to write books and do taxes than anything I ever had prior to the micro revolution; and once you get used to using them, they keep logs and notes, handle ad-

dresses, and generally make your life run better.

In *The Mote in God's Eye*, Larry Niven and I postulated a society in which nearly everyone carried a "pocket computer" that served as both notebook and entry to a universal memory bank. It looks as if that's going to come much faster than I thought.

I can't really help you choose between the Model 100, the Model 200, and the NEC PC-8201. I do think that once you've got one, you'll wonder how you lived without it.

ATARI ST

There still isn't enough software, and in particular there is no acceptable text editor for it, but in my subjective opinion, the Atari ST is still the most exciting machine of the year.

Whenever I say that I get flak from the MacTribesmen, who descend with fire and sword. "You early on trashed the Mac because there wasn't enough software. Now you're praising the Atari before the good software comes out."

There's some justice in that. The Atari, for all its merits, has yet to come out with a text editor as good as MacWrite. I keep hearing rumors of WordPerfect, but whenever I inquire, it's always Real Soon Now.

There'd be more justice in the MacTribesmen's views if Apple had sold the early Macintosh for a reasonable price. Instead, you got to pay two grand for the 128K-byte Mac just so that you could send Apple $995 for the upgrade kit, and you still didn't have color or a large-enough screen. Of course I didn't recommend the early Macintosh.

Nowadays Apple is market-driven rather than guru-driven, and it's a different story. The new Mac Plus is a good machine. On the other hand, I just don't see what the Mac can do that the Atari ST can't be made to do.

Certainly the Atari hasn't caught up with the Mac yet. There is some good software for the Atari, but not enough. Still, some, as we'll see in a moment, is so good that you might want to go buy an Atari ST just for those programs.

Atari continues to improve the ma-

(continued)

chine, and I'm told that not long after you read this they'll have upgrades like a blitter (a hardware gizmo that makes graphics software faster and easier to write) and a math chip to speed up floating-point calculations; but there is still a crying need for some pretty basic software, particularly a good text editor.

There is also some pretty bad software out there.

ANTIC SOFTWARE

Antic is a software distributor run by people who like computers. In particular, they like the Atari ST, and they're publishing some great programs for it.

They also have some dogs, but I don't want to discourage you from dealing with them. Just be selective. This is a company that sells stuff so good you might want to get an Atari ST just to have something to run it on.

Let's get the deadwood out of the way first. Some of their "entertainment" software, such as Mom and Me and Murray and Me, is so corny I think I'd throw my Atari away if I knew I had to run them. These are computer "biotoons," described as "artificial personalities—sort of like artificial intelligence with a sense of humor." What they really are is a ghastly joke, and to add insult to injury they're copy-protected. Actually, I guess that part is just as well. Antic has some other games and gubbage I wouldn't recommend.

That's the deadwood. Now for the jewels.

Antic's CAD-3D is one of the best programs I've seen for the Atari or anything else. It's not a "real" CAD system, in that it doesn't have dimensions and some of the design features of professional CAD; but what it does have is the ability to do things in three dimensions.

With CAD-3D you can draw an object, then travel about as if you were riding a camera boom, so that you can look at the object from any angle. The object and light sources don't move; you do. Once you've seen all you want, you can then rotate the object itself. When that happens, the light and shadowing change.

To make drawing easy you can

define a shape, then "extrude" it to give it depth. You can spin objects to generate a solid of rotation. You can snap points to a grid, connect dots, and do many of the things one expects from a more expensive CAD program.

All this takes place on a small monochrome screen; but when you've got it all done the way you want, there's a "superview" command that generates the object, in color, for the full screen, so you can see it in all its glory. One of the items that comes with CAD-3D is Stonehenge (restored). Zoom in close or back off and see the whole thing. It's glorious by moonlight.

CAD-3D was written by Tom Hudson, the same programmer who did DEGAS for the Atari ST. That one is published by Batteries Included, and some of the artwork astonishes visitors here. When Hudson did CAD-3D, he included the ability to save a particular view/rotation of your CAD-3D object as a DEGAS file. You can then bring up DEGAS and call up your object to color it, add text, and do whatever you like to make a poster or a book page or whatever.

Between them, CAD-3D and DEGAS make the Atari ST worth owning.

Antic also sells Flash, a communications program for the ST. I've only just got it running. It seems to be about as versatile as Crosstalk. I've been tempted to set the ST up in a place convenient to my desk and use it as a major machine just to get used to it. What stopped me was the need for a good text editor and a communications program. Now that I have Flash, I only need a text editor. More on Flash another time.

Interestingly, although Antic's ghastly joke programs are copy-protected, both CAD-3D and Flash urge you to make backup copies and put the original in a safe place.

Amiga and Atari

If I seem a bit more enthusiastic for the Atari ST than for the Amiga, there are a couple of reasons. One is that for all its faults—like the stupid menus that drop down whether you want them or not whenever you get any-

(continued)

where *near* the top of the screen—the Atari's GEM operating system works. AmigaDOS is incomplete, and some of its details are a matter of folklore, not documentation. If you like to amaze your friends, the Amiga is the machine; but you may also find that AmigaDOS will drive you nuts.

Not that there isn't some folklore in using GEM. I've only recently found out how to install things into the GEM desktop. At least one key move is nowhere documented. Grr.

The AmigaDOS defects aren't crucial for users. Most Amiga application programs don't require that you do anything with AmigaDOS. Which is just as well.

My main reason for being just a little shy with the Amiga has nothing to do with the machine or its software. It's a good system, and the software defects can and will be remedied, if not by Commodore then by the user community—provided that the Amiga survives.

That seems less problematical as I write this than it did a month ago. Commodore has had its Saturday Night Massacre, but the layoffs seem to have stopped, and the bankers who control the company seem willing to lend them more. One good year of sales and the Amiga is safe. Commodore also announced upcoming improvements.

I wish them well. It's a good machine; and as I've said before, I like the notion that Commodore will drive Atari to improve hardware, while Atari will drive Commodore to lower the Amiga's price; and the whole micro community benefits.



LITTLE COMPUTER PEOPLE

Little Computer People is a—I guess you have to call it a game—that runs on either the Atari ST or the Amiga. I understand there are versions for the Commodore 64 and Apple II, but I'm also told they're less interesting.

When you run the program, you discover that deep inside your computer there's a house, sort of like a dollhouse. If you watch that for long, a little computer person will appear to inspect it. Then he gets his suitcase and dog and moves in. About that time he turns to the screen and says something. Unfortunately, it's unintelligible.

Whatever it is must be interesting. I say this because I visited BYTE headquarters in Peterborough last week, and they had a machine set up with a little computer person in it. Stuck to the machine was a note threatening death and destruction to anyone who disturbed the computer or turned it off. This wasn't kindness. The BYTE staff was starving the little computer person.

It seems you have to feed them; this is done from the keyboard. The BYTE staff hadn't fed Henry, their little computer person, in a week. At least they think they hadn't. As it happens, I know two editors who took pity on Henry and snuck in to give him some food and water.

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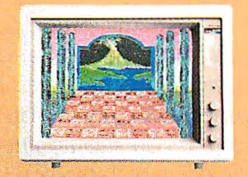




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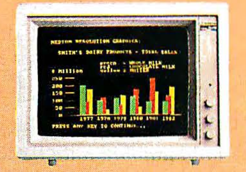
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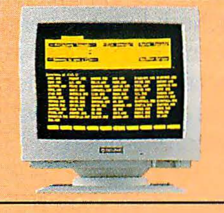
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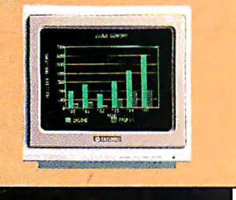
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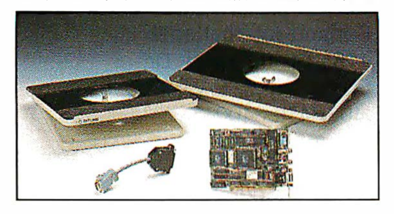
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Ken Sheldon, my long-suffering technical editor at BYTE, says Little Computer People is the equivalent of turning your computer into a Lava Lamp. I expect he's right.

REFLEX AND REFLEX WORKSHOP

Most small-business people I know just sort of muddle along. They know they're wasting money, and they ought to keep better records to show them how to save; but there's never time to set up a system because there's just too much else to do. If that's your trouble, help is at hand. Borland's Reflex and Reflex Workshop can probably solve your problem.

Reflex was the first "outside-developed" program published by Borland International. For the few who don't know, it's a database manager for IBM PCs and clones. Actually, it's more than that. Reflex will take data from other places, like Lotus 1-2-3, dBASE II and III, and PFS files; reorganize it; and issue reports. The program is something like what you'd get if you crossed a spreadsheet with a good programmable relational database.

Like all Borland products, Reflex comes with a thick book that explains, in great detail, just how to use the program. It also makes suggestions for applications. The book is complete and darned near worth the price of the program.

The result is something so easy to use, and so bulletproof, that one major publisher, Jim Baen of Baen Books, uses Reflex for all his accounting: inventory, keeping track of author royalties, foreign rights, sales and returns—the whole panoply of the publishing business. He does the calculations with Lotus 1-2-3 and uses Reflex to generate specialized reports that can track author sales, performance of cover artists, and the like.

The interesting part is that although he's using only Reflex and a PC, and has a very small administrative staff, he's selling as many books as many larger publishing houses. Moreover, the larger houses use big mainframe computers and employ dozens of people to foul up their records, and thus have unhappy authors, while Jim has one of the best reputations in the business.

I wish my other publishers would discover Reflex; and of course it's useful in other businesses. I can say, unequivocally, if you use a PC much at all, you should know about Reflex. Sooner or later you'll have an application.

If that weren't good enough, there's Reflex Workshop. Reflex does the job; Workshop shows you applications. The 400-page book that comes with Workshop has sections on creating accounting systems; inventory control; business expense reports; real estate management; production, operation, and quality control; and just a whole bunch of other stuff. Just reading this book can help a small business manager. The included disk contains Reflex templates for everything from schedule management to generating form letters. Between them, Reflex and Reflex Workshop may be the best bargain in software today. Highly recommended.

WINDING DOWN

I'm late with this, and probably over my space budget. The computer book of the month is Chris Devoney's *Using PC-DOS* (Que Corp., 1986). This is the best DOS book I know of. It covers everything and has lots of *examples*.

I should be home all next month, so maybe I can write some science fiction. Of course, General Graham is trying to involve me in setting up a graduate Space Academy, but maybe I can fob off most of that work on someone else. I probably won't, though. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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68000 WARS: ROUND 3

BY BRUCE WEBSTER

The bout resumes again as Bruce looks at four flavors of Macintosh

It's late July as I sit and write this; later, in fact, than it should be. However, the minor distraction of having a new wife and five more kids has slowed me down a little. Did I mention that we're moving to a new house in a week or so? One with a few more bedrooms and (hallelujah!) a private office. That should boost my productivity a little.

In the meantime, I'm sitting here in the family room, surrounded by computers (all of which are turned on, of course) and hoping that the oft-voiced rumors about ionized radiation from CRTs are just that: rumors. What have I got here? Four flavors of Macintosh: the original Mac, a Mac Plus (on loan from Apple), a HyperDrive 2000 (on loan from General Computer), and a Prodigy 4 (on loan from Levco); two flavors of Atari ST: a 520 (from BYTE) and a 1040 (on loan from Atari); one Amiga (again, from BYTE); and one Compaq (my own). I also have an Apple IIe, but it's up on the university campus right now. Out of all the computers here, the Compaq is the only non-68000 machine and, incidentally, the one I'm using to write this column. That might somehow be significant—but I doubt it. It probably just means that I'm too comfortable with NewWord 3 (a WordStar clone) to change.

So what's on tap for this month? True to form, I ran benchmarks on the four Macs, giving some real comparisons. I've got a look at some development software for the Atari ST and the Amiga, including a nifty 68000 assembler. I've also been playing with a beta copy of the Turbo Pascal compiler for the Mac and will have a brief report on that.

THE MACINTOSH PLUS

Well, Apple finally convinced me to upgrade the Mac 512K to a Mac Plus, which I did with some trepidation. I had heard numerous warnings about software incompatibilities, and such turned out to be the case. Right off the bat, I had to call Personal Computer Peripherals Corporation, the folks who are still graciously lending me a MacBottom hard disk, to get new boot software. You see, the MacBottom used to turn itself on automatically by sensing the +5-volt line in the serial port when you turned your Mac on. Apple, of course, dropped this line from the new serial ports on the Mac Plus. The new start-up program arrived quickly from PCPC and worked wonderfully. Better yet, I found I could partition the MacBottom into volumes that used the old Mac filing system and the new hierarchical filing system. So I now have one 10-megabyte HFS volume and several 1- to 2-megabyte MFS volumes.

Second, I discovered that some of the Mac software I had purchased more than two years ago (when I bought my original Mac) no longer worked, or worked erratically, on the Mac Plus. This included Microsoft Word (version 1.00), Multiplan (also 1.00), Dollars and $ense, and a few others. Sarah Charf at Microsoft graciously sent me a review copy of Excel to replace my rather antiquated version of Multiplan, but I have yet to receive an upgrade to Word, which has really limited my use of the Mac for word processing. On the other hand, most of my more recently acquired software works just fine, and it's nice having the 1 megabyte of RAM and the 800K-byte disk drives (along with the MacBottom hard disk).

Am I glad I traded in for a Mac Plus? Well, yes. Overall performance seems to be much better, I like the extra RAM and disk space, and it's nice to have the most recent model. To quote Oliver Wendell Jones (from "Bloom County"): "Hackers, as a rule, do not handle obsolescence well." If I were to buy a Mac off the shelf today, I'd get a Mac Plus.

MACINTOSH UPGRADES

Two firms, General Computer Company and Levco, are competing head to head in turning that little beige toaster on your desk into a high-powered workstation. Both upgrades—the HD 2000 from GCC and the Prodigy 4 from Levco—were shown at the MacExpo in San Francisco last spring (where I reported on them). Now both units are close to shipping, and both firms have been kind enough to lend me beta units for evaluation.

General Computer Company is famous for having brought out the first (and for a long time the only) internal hard disk for the Macintosh, the HyperDrive. While reviews for the HyperDrive have been mixed (see Gregg Williams's review in the December 1985 BYTE), GCC has still been able to capture a large share of the hard disk market for the Mac. However, growing competition has induced GCC to look at enhancing its product line, and the result is the HD 2000.

(continued)

Bruce Webster, a consulting editor for BYTE, *can be reached c/o* BYTE, P.O. Box 1910, Orem, UT 84057, *or on* BIX *as bwebster.*

Table 1: *Benchmarks for four versions of the Macintosh, using a program written in TML Pascal. All figures are times in seconds, unless otherwise indicated.*

	Mac 512K	Mac Plus	HD 2000	Prodigy 4
Performance				
sieve	4.8	6.7	4.3	1.2
matrix	5.9	7.6	4.8	1.6
sort	9.4	12.6	8.8	2.6
FLOPS	1578	1468	4651	10,480
(floating-point ops/sec: add, subtract, multiply, divide)				
Graphics				
vertical lines with skew:				
0	12.1	12.9	12.4	4.8
1	184.8	87.2	82.8	24.0
20	185.6	87.2	83.1	24.0
100	186.0	86.8	83.9	23.9
horizontal lines with skew:				
0	3.0	3.4	3.2	1.0
1	7.2	5.6	5.4	1.6
20	23.8	12.9	12.6	3.7
100	93.7	43.8	42.5	12.1
rectangles	23.8	17.8	17.4	9.1
circles	18.3	9.4	9.4	2.8
windows	13.6	14.4	13.9	4.4
text	16.6	12.9	11.7	3.2
I/O—Floppy Disk (128K-byte file in 512-byte blocks)				
write	40.5	14.1	12.1	6.7
read	7.3	7.8	7.8	5.8
random	50.9	37.3	36.6	34.5
I/O—Hard Disk (128K-byte file in 512-byte blocks)				
write	——	5.4	5.0	6.9
read	——	4.3	2.8	6.4
random	——	22.2	8.1	8.6

Table 2: *Some C benchmarks for the four Mac versions, giving floating-point operations/second* (FLOPS), *Whetstones/second* (WHETS), *and Dhrystones/second* (DHRYS).

	FLOPS	WHETS	DHRYS
Mac 512K	1476	7973	991
Mac Plus	1344	7278	772
HD 2000			
regular	4103	48,504	1106
HD special	15,801	130,719	——
Prodigy 4			
regular	9758	105,820	3201
HD special	45,467	271,493	——
P4 special	48,077	468,750	——

The HD 2000 consists of an internal 20-megabyte hard disk, a 1.5-megabyte increase in RAM, a 12-megahertz 68000 processor (to replace the Mac's), and a 68881 floating-point coprocessor (to speed up number crunching). Like the original HyperDrive, all this fits within the original Macintosh case, putting a lot into a little footprint. The system boots up from the hard disk automatically on power-up, so you don't have to go through any special procedure. A disk cache and a RAM disk are automatically created according to configuration information that you can modify using some of the system software.

The hard disk is organized into "drawers" that can be mounted or dismounted via a special desktop menu (which itself is installed using a desk accessory). Unlike some hard disk systems that partition the available disk space into fixed chunks, the drawers expand and shrink in size to accommodate the files they contain. It's possible to assign a password to a given drawer, allowing only authorized users to access it.

The strength of the HD 2000 appears to be the system software, which allows great flexibility in allocating space on the hard disk and in configuring the system to suit your purposes. The drawback—as we'll see in a little while—is that you don't get much of an improvement in performance.

As I have said before, the Prodigy 4 from Levco is for power freaks only. Though the price has come down about $2000 from what Levco was quoting last spring, $7000 is still a lot to pay for an upgrade to a $2000 computer. But what an upgrade! For your bucks, you get the following: a 16.67-MHz 68020 processor, a 68881 math coprocessor, 4 megabytes of RAM using 1-megabit chips, and a 20-megabyte hard disk. This turns your desktop Mac into a machine that appears (by the benchmarks) to run rings around a VAX-11/780.

If system software is the strength of the HD 2000, it's the weakness of the Prodigy 4. The current boot sequence is awkward, though it apparently will be improved in the next Prodigy ROM revision. Configuration software is not particularly powerful nor flexible. Obviously, the folks at Levco have got to put more time and effort into this.

Now for the good stuff: benchmarks. Table 1 shows the results of running my benchmark program (written in TML Pascal) on a Mac 512K, a Mac Plus, the HD 2000, and the Prodigy 4. All but the Mac 512K had the new ROMs and the latest System and Finder. The overall winner is the Prodigy 4, usually by a wide margin. Note a few interesting trends. On straight performance benchmarks, the Mac 512K beats the Mac Plus, though I have no idea why. On the graphics, as reported a few months ago, the Mac Plus easily outperforms the Mac 512K, but the HD 2000 barely improves upon the Mac Plus. The Prodigy 4, on the other hand, beats the Mac Plus and the HD 2000 by a factor of two to four in performance and graphics and by almost a factor of two in some floppy disk benchmarks. However, the Prodigy 4 hard disk is slower than either the HD 2000 drive or the MacBottom on the Mac Plus.

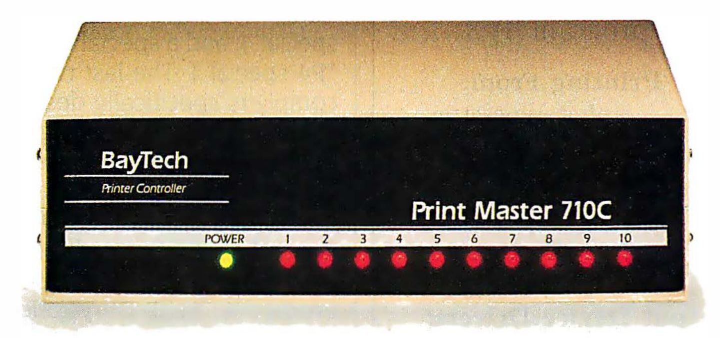
Table 2 is a clearer indication of power differences. Three

(continued)

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Because Print Master is a very flexible device, you can set it up to fit your application, even if your application changes.

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You configure Print Master's ports for any combination of printers and computers by answering questions from easy-to-follow menus. For example, with the ten port Print Master, nine computers can share one printer, eight computers can share two printers, seven computers can share three printers, and so on, to one computer which can share nine printers. You can also menu-select the disconnect time-out, form feeds, etc. and on serial models, the configuration of individual ports to translate for printers and computers using different configurations.

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Since Print Master can accept data faster than your printer (up to 19.2KB serial or 5,000 characters per second parallel), you can send a print job to Print Master's standard 512K buffer and then go on to another project. All users connected to Print Master can send data to this common pool buffer, and they can be doing it simultaneously, even if no printer is available. Data is stored in the buffer until it can be sent on a first-job-in first-job-out basis to the selected printer. If you need more memory than 512K, Print Master is optionally available with one megabyte buffer.

If several users are sharing one printer, printer sharing via Print Master is completely automatic. There are no codes to send. You simply perform your normal print operation. If you are sharing several identical printers, connection is also automatic. Again, you perform your normal print operation and are connected to the next available printer on a first-come-first-serve basis. Print Master will send data to all printers simultaneously to keep your printers running at full capacity.

If you are sharing several different printers, such as a laser-jet, a dot matrix and a plotter, and you wish to select a specific printer, you do your normal print routine and also send a printer select code (which you can define yourself) before the first characters of your data. The data is then routed to the selected printer. It's that easy.

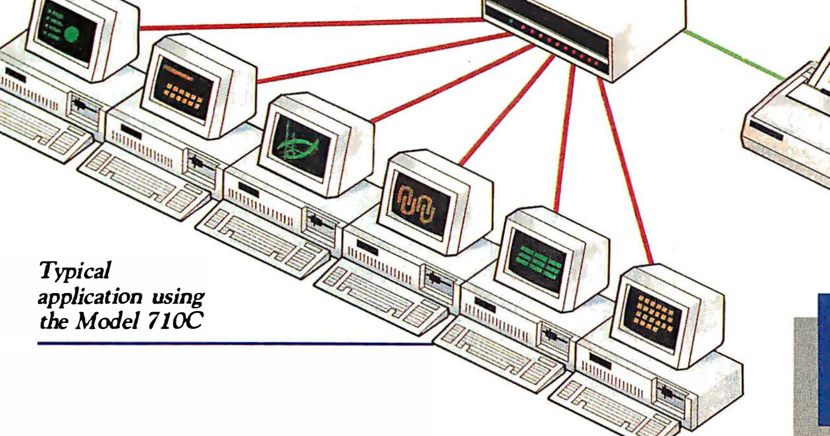
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different programs were involved here: a floating-point benchmark, a Whetstone benchmark, and a Dhrystone benchmark. All were written in Mac (Consulair) C, and three versions were produced: a "generic" version for any Macintosh; a special version for the HD 2000 (labeled "HD special"); and a special version for the Prodigy 4 (labeled "P4 special"). The last two were produced using Mac C compilers specifically designed for each of the two machines. What's interesting is that the Prodigy 4 is (by deliberate design) able to run code specially produced for the HD 2000, but the reverse is not true. Furthermore, the Prodigy 4 runs the HD 2000 code two to three times faster than it runs on the HD 2000. As for the "VAX-on-your-desk" claim, note the Dhrystone benchmark for the Prodigy 4: 3201 Dhrystones/second. According to the source file for this benchmark, this exact same program runs at a clip of 1612 Dhrystones/second on a MicroVAX II and 2083 Dhrystones/second on a VAX-11/785. Not too shabby.

Would I recommend either one? In both cases, the issue is price/performance; that is, does the increased performance of the machine warrant the price? It probably doesn't for the HD 2000; even with the boost in floating-point calculations, there just isn't a sufficient increase in power to make it worth the price. The Prodigy 4 is simply out of the reach of most of us. On the other hand, for engineering and scientific firms looking to put high-powered workstations (like the MicroVAX) on individuals' desks, the Prodigy 4 can seem like a real bargain. Especially since the folks at Levco claim that they will be shipping UNIX for it by the time this sees print. Given a choice of one or the other, I'd choose the Prodigy 4—but I couldn't afford to put out the bucks for either one.

THE 1040ST

As I mentioned last month, an Atari 1040ST finally showed up at my front door, and I like it just as much as I thought I would. The 1 megabyte of RAM is great, TOS in ROM is great, the built-in disk drive and power supply are great. Given the development software that has shown up (discussed below) and the ST books from Abacus (discussed last month), I'm having a wonderful time writing code on the machine. I also got TOS in ROM for the 520ST, so now I've got two useful ST systems around the house. Right now, the 520ST is mostly occupied by my children, who spend vast amounts of time playing Time Bandit, Major Motion, and Mudpies, all games from MichTron Industries. (And I must confess that I've put in a few hours with Time Bandit and Major Motion myself.) Anyway, look for some Mac/ST/Amiga/IBM PC benchmarks in an upcoming column.

MEGAMAX C FOR THE ST

I finally—finally!—have a decent C development system for the Atari ST: Megamax C. Hippo C came and (mercifully) went; DR/Alcyon C was a pain to use and poorly documented; and I have yet to get my hands on a copy of Lattice C. Given Megamax C, I'm not sure if I really care to.

(continued)

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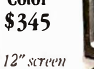
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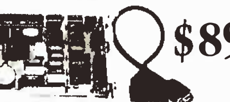
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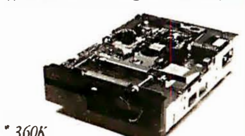




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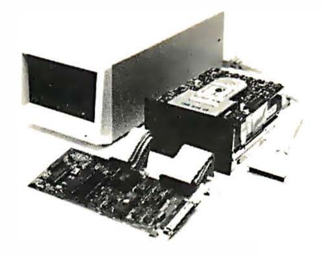
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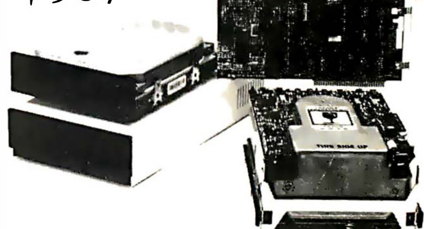
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Megamax C comes with a suite of programs: editor, compiler, linker, disassembler, code optimizer, librarian, and shell. It also has the requisite header files and libraries so that you can make calls to GEM AES, GEM VDI, GEMDOS, BIOS, and XBIOS. The shell puts you into a custom menu (drop-down) environment that lets you quickly go from editor to compiler to linker to finished program. It even has delete-file and rename-file functions, though I wish it also had a copy-file function. I just move all the important stuff onto a 440K-byte RAM disk (on the 1040ST, of course), and the whole system screams along.

The program editor is the nicest I've seen on the ST and comes the closest of any of those to emulating some of the Mac program editors (like Bill Duvall's EDIT). You can have multiple windows open, editing multiple files. You can use the "click-drag" mouse function to select blocks of text and transfer code between files. You can set tabs and toggle auto-indent mode (something of an obsession with me). You can even set an "auto-save" mode that will automatically save your program out to disk every few minutes.

The compiler is fast, as is the linker. Running off a RAM disk, I was able to compile a 500-line program—including two header files—in about 6 seconds; linking the same took another 12. With the "make" option (which allows you to edit your own link-and-compile file, then just run that from the main menu), the time is even quicker. If errors occur during compilation, the shell is smart enough to put you back into the editor and open two windows: one for your source code file, and one for the errors listing. It makes debugging a lot quicker than it would be otherwise.

I'll save most of the benchmarks for a future column, when I can get a full suite up and running. But just for idle comparison with table 1, I got 3.9 seconds for sieve; 6.0 for matrix; 4.4 for sort; and 3406 floating-point operations/second. And that was not using register variables.

PRODUCT OF THE MONTH: HISOFT DEVPACST

I wasn't planning on having an assembler be the product of the month again, but that was before version 1.22 of HiSoft DevpacST showed up, along with a prerelease (version 0.16) of the Amiga version, DevpacAM. DevpacST is a complete 68000 assembly language development package, with an integrated editor/assembler, a debugger, a linker, the necessary include files, and a few sample programs. The 150-page manual comes in a small two-ring binder that lies flat; the manual itself is well written and well organized. And, as a welcome bonus, you get the *Motorola 68000 Programming Pocket Reference Guide*, a compact 120-page booklet listing all the 68000 instructions. The disk is not copy-protected, but then, not much development software is (thank heavens). The whole package costs only $79.95.

Getting into the editor/assembler (GenST) is easy: Just double-click on the icon, and you're ready to go. You can now start typing in your program or load in an existing file. The editor itself is fast and fairly easy to use. It ac-

(continued)

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cepts a subset of WordStar commands for cursor movement, as well as using the mouse and scroll bars. There are find and replace commands, a print-block command, and options to set tab length and toggle an auto-indent mode. It isn't a tremendously powerful or flexible editor, but it gets the job done nicely, and almost all commands can be done from the keyboard for those who don't like mice. I do have one major complaint, though. I can find no way of copying a block of text from one file to another. It is true that you can mark a block of text within a file, then move it, delete it, or save it to disk. But once you load in a different file, that block is "forgotten," and there is no mechanism for pulling text off the disk into the file you're currently editing. I hope that's fixed in future versions, because it's a real limitation.

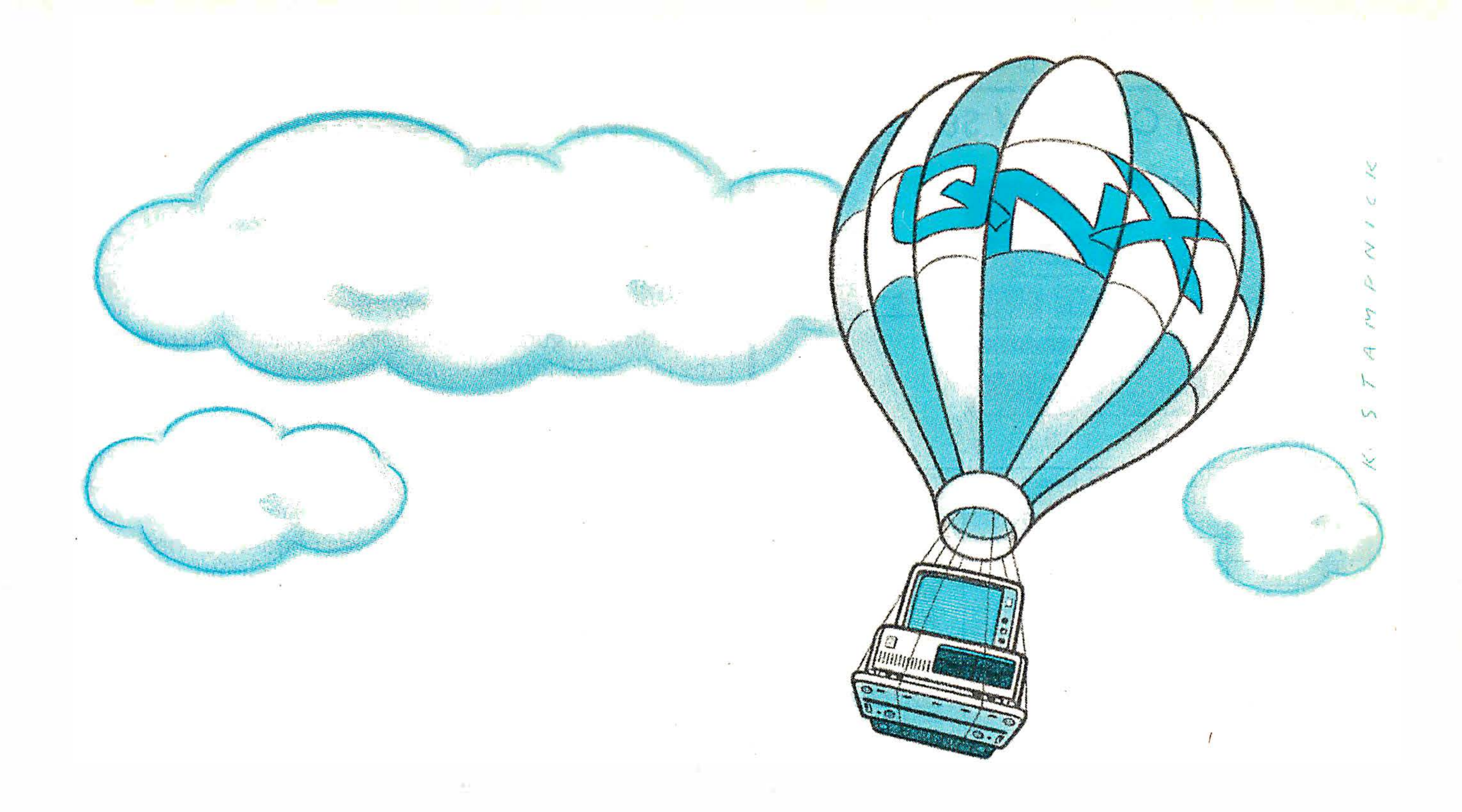
The assembler is invoked from within the editor. It brings up a dialog box that lets you name an output file (if desired) and also indicate a listing destination (none, screen, printer, disk file). The assembler is quick and runs in two passes, the optional listing being generated during the second pass. You can pause the assembly by holding down the Alt key or abort it with the Esc key. Errors are listed as they are encountered. Once the assembly is done, any keystroke takes you back to the editor. If there were errors, you can then use the "Jump to Error" command to go to the errors in succession.

The assembler is full-featured, supporting the 68000 instruction set, complex expressions, a number of options (debugging information, macro expansion, case sensitivity, etc.), include files, alignment operators, printer commands, conditional assembly, macros with up to 10 parameters and with unique label generation, and so on. Labels can be just about any workable length; the first 16 characters are significant. You can choose to produce ready-to-run code or linkable code modules. In short, it has almost everything you'd want in an assembler.

Once you've produced working code, you need to exit GenST to run your program. What, then, if you have problems? Well, you can invoke MonST, the debugger that comes with DevpacST. When you run it, it brings up four displays on the screen: registers, memory, disassembled listings, and a command line. You can now set breakpoints, modify memory, single-step through your code, "interpret" an instruction (for example, make a trap call without having to single-step through the entire trap handler), disassemble areas of memory, and so on. If you included the D+ option in your source code, MonST pulls up the symbol table and uses your labels in the disassembly. The debugger is not as slick as Metascope (see below), but it still gets the job done. It uses a different location in RAM for its screen display, so it doesn't interfere with what your program writes to the screen (and vice versa). MonST actually comes in four flavors: GEM or TOS, and resident or user-invoked. All four versions are on the disk; you can choose the one that best suits your needs.

The linker (LinkST) supports the GST linker file format, but not the DR (TOS) format. The folks at HiSoft give three reasons for this: first, the DR spec wasn't made available;

(continued)



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second, it appears (to them) that the DR format is "very restrictive"; third, (according to them) support from third parties is greater for the GST format. I don't know how valid those arguments are, nor how much of a limitation the lack of DR format support is. Also, the assembler lets you create only one module per binary file (though that module can have multiple XREFs and XDEFs), so you can't really build libraries with the assembler. Reference is made to using a "library creation program" to do the trick, but no such program is included with this version of DevpacST. On the other hand, I haven't had much occasion to use the linker, so I'm not really concerned.

By the way, the Amiga prerelease worked nicely. It had only the editor/assembler (GenAM), but that was enough for me to do a fair amount of coding, modifying a sample program that came with it (see below). I suspect it will be shipping by the time you read this; if so, consider it strongly for your Amiga assembly language programming needs.

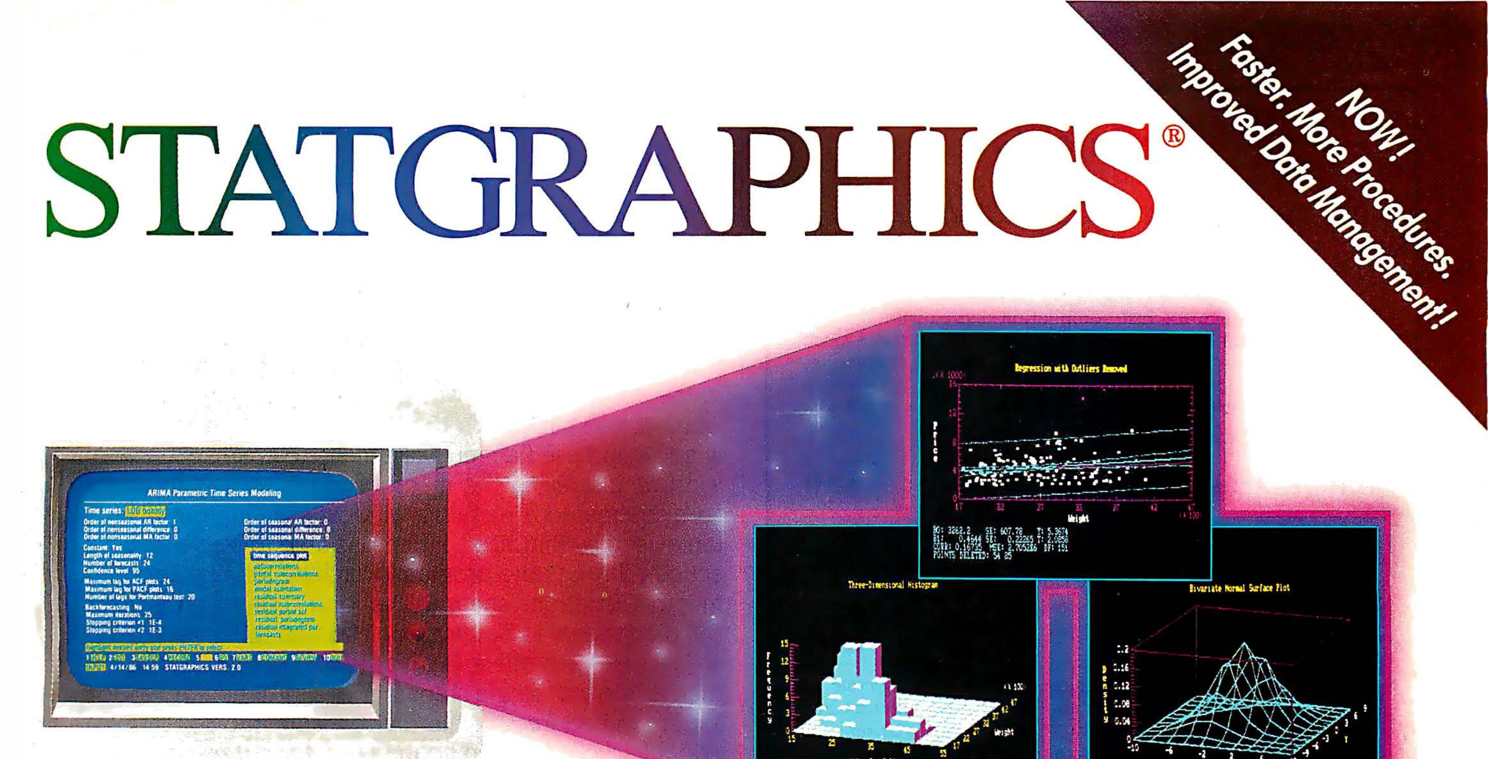
DevpacST is a well-designed, well-implemented package with good documentation and an excellent price. It has done more to get me playing around with the ST than any other language or development system I've used to date, and the Amiga version threatens to do the same. As further proof of its utility, at least one commercial package for the ST—the arcade game Star Glider, written by Jez San and published by Rainbird Software—was developed entirely using DevpacST. HiSoft, and especially Andy Pennell, should be congratulated for a job well done.

METASCOPE

The Amiga version of Devpac came with a sample program that brought up a small window and displayed (in hexadecimal notation) the amount of free memory, updating it whenever the value would change. The source code had the comment, "Conversion to decimal is left as an exercise to the reader!" Fine, I thought, and I exercised myself, scouring a collection of 68000 texts for a binary-to-decimal routine. Unfortunately, most handled only 16-bit values, since the DIVU instruction on the 68000 is a 16-bit instruction, and I needed to be able to convert 24-bit values. However, the text *Programming the Macintosh in Assembly Language* (by James W. Coffron, Sybex, $24.95) had a nice routine that handled 32-bit values by using a table of divisors. I keyed it in, adapting it as I went and dropping the sections that dealt with negative numbers. Unfortunately, the new, improved program (called FreeMem) insisted on dropping the last decimal digit: Instead of printing "181253 bytes free," it would print "18125 bytes free." And so I went to the bookshelf and dug out a hitherto unused copy of Metascope, a window-based debugger for the Amiga.

What a nice product. A quick scan through the manual—most notably Chapter 5, "Usage"—showed me how to set things up. When I ran Metascope, a status window appeared, showing me the contents of the 68000's registers (16 of them, plus the status flags). A few quick pull-down menu commands brought up a second window showing

(continued)



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a disassembled listing of FreeMem. I scrolled through until I found the binary-to-decimal routine (called BinToDec), clicked on the memory location of its first instruction, and used the Once command, which ran FreeMem until it hit that location. At that point, register A0 had the address of the string FreeMem was going to print in its own little window, so I clicked on the contents of A0 in the status window and used a menu command to create a memory window, displaying the memory at the string's location.

I also created a memory window showing the divisor table used by BinToDec. I then was able to single-step execution through the program, watching the registers and memory locations change. The loop counter (in register D2) didn't seem to be synchronized with the divisor table, so I let FreeMem run until it hit the start of BinToDec again, then I started single-stepping again. When BinToDec loaded the address of the divisor table into register A1, I double-clicked on the contents of A1 in the status window, changed the value to start at the second table entry, then let the program run. Sure enough, it worked this time. Got out of Metascope, got into GenAM, edited FreeMem, assembled it, then ran it. Fixed!

Metascope does a lot more than I've explained here. Other window types (breakpoints, hunks, symbols) can be created. Logging to disk is supported. Various forms of single-step and continuous tracing are available. Lots and lots of menu options are available for the different window types, more than I care to describe here and possibly more than I'll ever use (unless I get really adventurous).

What can't Metascope do? Well, Chapter 6 (entitled "Limitations") points out that Metascope can't debug any tasks or processes that your program might start; that it can't be used with programs that take over trap handling; that single-stepping through time-critical portions of code where your program must respond to the system or has seized control of certain resources can cause crashes; single-stepping through certain system routines can also cause crashes; and so on. In short, the Amiga system is a complex multitasking environment, and Metascope can't handle all possible situations in it. I'm not sure, though, if any debugger on the Amiga will be able to handle those problems. As far as I can tell, Metascope is the best debugger for the Amiga. It's easy to use, very flexible, and works well.

TxEd

Up until recently, most of my program editing on the Amiga has been done with the Lattice Screen Editor (LSE), with occasional use of ED or EDIT, the two system editors that come with the Amiga. Then Charlie Heath of MicroSmiths Inc. sent me the latest version (1.3) of TxEd, and I've dropped the other three completely. TxEd is a fast, slick program editor that eases a lot of the pain of entering code on the Amiga. What's more, it's quite a bit smaller than LSE, using less disk space (or, for that matter, RAM).

Yes, get TxEd if you're editing almost anything on the Amiga. It has the usual functions, though it tends to use the right Amiga key (i.e., the red "A" key to the right of

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the space bar) instead of the Control key for keyboard commands, making keyboard entry more difficult than it should be. If you have sufficient RAM available, you can start up another command-line interpreter, or even another instance of TxEd (which is an actual, complete copy of the program, not just two windows for the same edit session).

What do I like about TxEd? Just about everything. It's fast. It's easy to use. It does almost everything I want it to and, for you mouse haters, does most of it from the keyboard.

TxEd isn't perfect, though. Its greatest flaw is with the Open command, which lets you leave the file you're working on and start editing a new one. It does not save any changes you have made in the file you're leaving, nor does it warn you (via a dialog box) that you're going to lose those changes. Instead, before doing an Open, you are supposed to look at the top of the window, where it says "TxEd." If the "x" is uppercase (i.e., if it says "TXEd"), you know you are supposed to do a Save before doing the Open. Unacceptable user-interface design, if you ask me. I can just see some poor hacker at 3 a.m. hastily making changes to several files, confident that the program will compile and run this time, only to discover that a Save wasn't done before one of the Open commands and all the changes to a particular file are lost. I hope Charlie fixes this defect in the next version of TxEd.

My only other grumbles are more of a "wish list" variety. TxEd does support auto-indent, but to do it you have to hit the Enter key (over in the numeric keypad) rather than the Return key; as a proficient touch-typist I find that awkward, because I have to stop and think about what key to hit at the end of each line. I'd rather just have a menu selection that toggles auto-indent mode, as the editor in Devpac and many other program editors do. I also wish TxEd let you set the tab length (again, as Devpac does). TxEd assumes a tab length of eight, which for my taste is too long for C or Pascal and too short for assembly language.

Besides TxEd, a few other utilities are on the disk. Two programs, AmigaText and IBMText, are used to convert text files for transmission back and forth between an Amiga and an IBM PC. Another program, ReTab, recreates the tab characters that ED (one of the system editors, remember?) converts into spaces for you. And the final program, PROFF, is a file-printing program that lets you insert formatting commands into TxEd files and have them come out nicely on your printer.

Despite my grumbles, TxEd is the best program editor I've seen for the Amiga. And it's only $59.95 for the latest version along with the additional utilities.

TURBO PASCAL FOR THE MAC

Yes, Turbo Pascal for the Macintosh really does exist. I recently received a beta copy (1.00B) from Borland International and spent some time playing with it. It still has a few glitches and is not 100 percent Lisa Pascal–compatible yet, but it does provide the high-speed integrated

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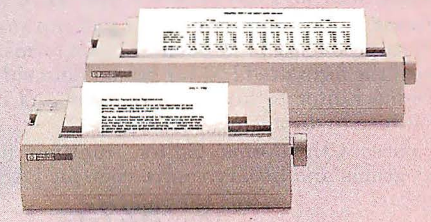
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development environment you've come to expect from Borland. I was able to convert several TML Pascal programs with just a few changes, mostly at the start of the program (with different compiler options), as well as some file I/O commands in the programs. Turbo uses Open( ) as opposed to TML's Assign( ); also, Turbo does not (yet?) support file I/O using Get( ) and Put( ), but instead uses the Read( ) and Write( ) commands just like Turbo Pascal on the IBM PC.

(continued)

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Table 3: *Some preliminary benchmark results for two Pascals for the Macintosh. The program tested consisted of about 660 lines of Pascal source code.*

Turbo Pascal:	
compile to RAM:	3.8 seconds
compile to disk:	10.2 seconds
change, then run:	3.8 seconds
TML Pascal:	
xfer to compiler:	8.3 seconds
compile:	73.7 seconds
include files:	43.4 seconds
program itself:	30.3 seconds
xfer to link:	6.6 seconds
link:	33.0 seconds
xfer to run:	1.8 seconds
change, then run:	196.3 seconds

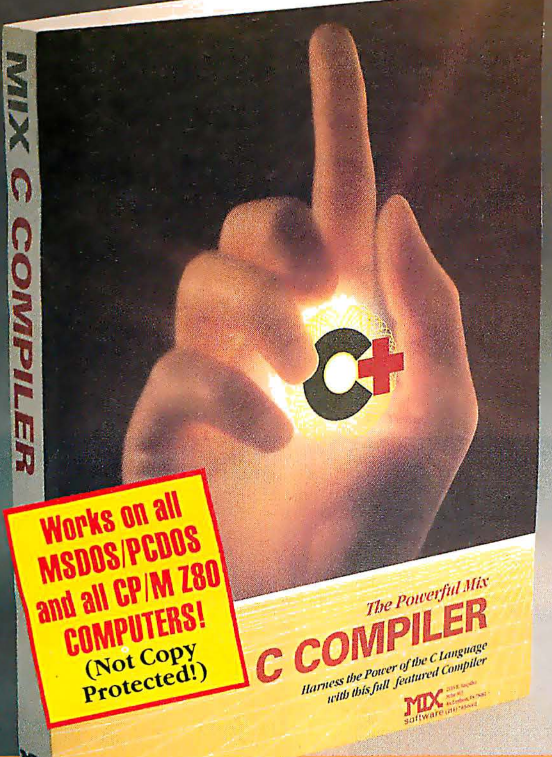
I suppose you're itching for some benchmarks. Well, I won't publish execution benchmarks, since I'm still using a fairly early beta version, but I will say that they were comparable to TML Pascal right down the line: faster for some routines, slower for others. The only place where TML had a clear advantage was in real arithmetic, where it was about twice as fast as Turbo Pascal (both were using the SANE library, too). However, some compile and link times for a program that was about 660 lines long are given in table 3.

A few important factors account for some of Turbo's speed. First, the library (unit) files are in a format that doesn't require any headers or declarations to be read in by the compiler. Second, the linking stage is integrated with the compiling stage. You can produce units (libraries) with Turbo Pascal; you can also link in external assembly language routines that follow the MDS format. You cannot, though, produce linkable object code. By comparison, TML Pascal allows you to produce either .ASM (68000 assembly language source) or .REL routines, lets you link in MDS format routines, and (with version 2.0) lets you create units. Also, Think Technologies has by now started shipping Lightspeed Pascal; look for a review of this in a few months. In short, Borland will have plenty of competition on the Macintosh. Look for Turbo Pascal to ship in mid-November, with a price of $99.95.

In the Queue

Next month, I'll look at some hardware for the Amiga, software products you might want to consider for Christmas presents, and the latest in idea processors for the Macintosh. Until then, I'll see you on the bit stream. ■

Various folks helped in putting this column together, including Doug Gilbert at Levco; Elena Gonzales at General Computer; Doedy Hunter at Apple; Neil Harris at Atari; Jay Friedman at Consulair Corporation (who provided source for many of the benchmarks used); and Sandra, who's discovering what it's like being married to a computer freak, but who loves me anyway. Thanks, all.



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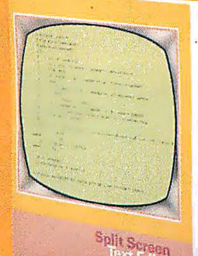
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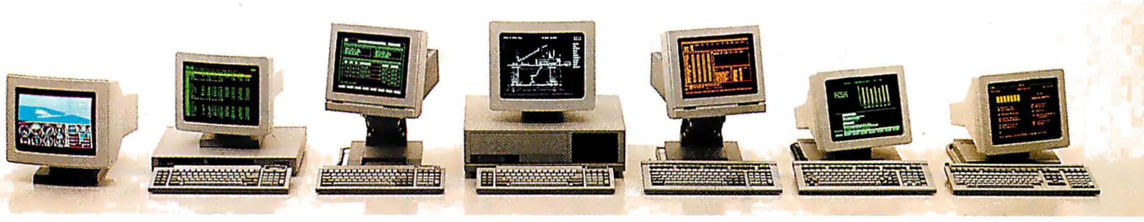


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TECHNICAL CURIOSITIES

BY WILLIAM M. RAIKE

Vending machines now offer on-line information at bargain rates

At this time of the year, there's usually a lull in the announcement of new Japanese personal computers. I can't be sure whether it has something to do with the onset of the rainy season, or whether we're in between the two major Tokyo computer shows of the year; in any case, it gives me a chance to talk about some interesting sidelights, including some services and equipment you can find here in Tokyo that you would never see elsewhere.

A VENDING B-BOX

On a recent trip to Akihabara, the Tokyo district that serves as the mecca of consumer electronics, I happened to be walking through a showroom in one of the major computer department stores when I literally stumbled across still another coin-operated information service.

Vending machines appear everywhere in Tokyo, for everything from booze to batteries, but now they've got one for on-line data. The one on which I stubbed my toe was green and about the size of a Coke machine, with a sign proclaiming it to be a "B-Box." I never did find out what the name is supposed to mean, if anything, but it was easy to figure out how to work it. You insert a copper 10-yen coin (worth about 6 cents at the present rate of exchange) into the slot, look at the numbered menu and operating instructions on the color display screen, and make your selection using a keyboard that resembles the one on a Touch-Tone telephone. The machine then dials up a central computer and queries the database stored there.

The B-Box service is new, so there are only a hundred or so machines around town, concentrated in commercial locations that cater to young people. The database at this time consists of information that's primarily of interest to younger people: part-time job opportunities, entry-level help-wanted announcements, and information on various special-interest schools and classes. The information is updated on a continuous basis. Your 10 yen buys you a 10- by 15-inch page of hard copy, in a clear 24- by 24-dot kanji font, printed by a kanji printer in about 30 seconds and ejected through a slot. The front of the form has the B-Box logo and promotional information printed at the head and foot of the page; the back is a printed flier containing a variety of advertising.

I've seen various public database terminals before, one of them located at the train station in Matsumoto to give free local travel information. But the B-Box is coin-operated and differs from the others in that the database is updated fairly frequently so that the information is quite current. I wouldn't be at all surprised to see a similar service offered sometime soon for locating apartments for rent; with Tokyo's chronic housing shortage, it would be a natural supplement to the weekly magazines that now fill that need.

THE NEC PC-9801VM2E IN THE U.S.

Many of the letters I receive from BYTE readers contain requests for information and assistance in finding a way to do Japanese-language word processing in the United States. Faculty and students in Japanese-language departments at several universities have expressed a real need for that capability. Unfortunately, since I know of no adequate hardware and/or software that can let the IBM PC and its work-alikes (or other computers available in the U.S.) handle Japanese, I've had to recommend that they contact someone in Japan to import a Japanese personal computer.

Evidently NEC, the largest personal computer manufacturer in Japan, has become aware of this potential market. The company recently announced that a version of its best-selling 16-bit personal computer, the PC-9801VM2, will be available shortly in the U.S. I've discussed NEC machines at length in earlier columns, so I won't go into detail here. In summary, though, this computer is based on NEC's V30 microprocessor, running at either 8 or 10 megahertz. (The V30 is completely software-compatible with the 8086 processor and also offers an on-chip Z80 emulation mode.)

The export model will be called the PC-9801VM2E (the E stands for "export"), will contain 384K bytes of RAM and two 1.2-megabyte floppy disk drives, and will be supplied with either a monochrome monitor or an optional color monitor. The machine comes with 192K bytes of graphics VRAM in addition to the standard RAM and supports 640- by 400-dot graphics. Kanji characters are dis-

(continued)

William M. Raike, who has a Ph.D. in applied mathematics from Northwestern University, went to Japan in 1980 looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer. He can be contacted c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

I came across my first BBS in the Japanese language just the other day.

played on the screen in a highly legible 16-dot font. The Japanese-language features include the JIS No. 1 and No. 2 kanji character sets, for a total of nearly 7000 kanji characters in addition to the alphanumeric and katakana character sets.

In order to provide a complete system suitable for Japanese-language processing, NEC is also going to supply an export model of one of its popular 24-pin kanji printers, the PC-PR201HE.

NEC will make the necessary modifications to the export models to ensure that they meet appropriate U.S. safety standards and FCC emission standards.

In Japan, NEC sells Japanese-language versions of either the MS-DOS or CP/M-86 operating systems separately from the computer; presumably, the company will bundle an operating system with the computer for the export market. Be warned, though, that the PC-9801VM2 is not fully IBM-compatible, although it will run much MS-DOS software. Also, NEC hasn't said whether it will provide English-language documentation. In any case, the documentation is unlikely to be any better than the sorry lot that comes with the computer here in Japan. It will be interesting, too, to see what kind of support a foreign-language computer gets from NEC's U.S. sales and service organizations.

JAPANESE-LANGUAGE BBS

Another recent Akihabara discovery I happened upon had to do with bulletin board systems and computer networks. Although personal computer users in Japan have lagged behind their U.S. counterparts in using computers to communicate, that's been gradually changing. Besides U.S.-based services like BIX, The Source, CompuServe, and MCI Mail, which are accessible in Japan via the Japanese international telephone company's Venus-P public packet-switched network, a number of local English-language BBSs have been in existence for some time. But I saw my first one in Japanese just the other day.

One of the better computer department stores, Laox Computer Media, employs a technically competent sales staff. During a recent visit to their showroom to clear up a question or two, I noticed a brochure describing "LAOX NET," a "pasocom (personal computer) communication system." It turned out to be a BBS, running on an NEC PC-9801VM4, operated by the Laox store as a free ser-

vice to customers. Customers fill out an application at the store and receive an ID and password by return mail.

The board operates at either 300 or 1200 bits per second, and it offers bulletin board and electronic mail services. Text can be in *either* katakana alone or in conventional Japanese, which is a mixture of kanji characters and the hiragana and katakana phonetic alphabets. The ordinary alphanumeric character set is supported also, of course. Prompts from the system are all in katakana, however, making it possible for customers using terminals or computers with minimal or no kanji capability to communicate with the system.

Because communication between personal computers in Japan is in its infancy, Laox provides basic, easy-to-follow instructions for connecting an acoustic coupler, modem, or "modem-phone" (telephones incorporating primitive no-frills modems are available, although at outrageous prices compared to customary U.S. prices). The store also provides details about logging on to its net using half a dozen different models of personal computers. Laox also sells the necessary communication software.

The salesman I talked to, Ishikawa-san, said that the system had been in operation for a little more than a month and that more than 200 users had registered. Usage is brisk. With two new companies planning to compete with NTT (the Japanese domestic telephone company), not to mention the imminent prospect of competition within Japan for international data communications business, it seems to me that the Japanese won't lag behind the U.S. for long in using personal computers for communications. In fact, a number of local banks have been experimenting for several months with allowing "pasocom" users to query on-line bank computers about the balance in their accounts, and such trends are likely to continue despite the terrifying security implications.

I've got a question, though. In view of the limited choice, high prices, and primitive capabilities of Japanese-made modems sold here, why aren't any of the major U.S. brands sold here? For instance, the Hayes Smartmodem 2400 I bought in Chicago last year works perfectly here at both 1200 and 2400 bps, and it supports both Bell and CCITT specifications (i.e., U.S. and international telephone standards; Japan uses the latter) at 1200 bps. Time is short, though; some new and sophisticated modems now being designed should be on the Japanese market by early next year.

Because of business pressures and other reasons, this will be my last BYTE Japan column. My thanks and best wishes go to all the BYTE readers whose questions and encouragement made writing the column a pleasure and to the entire BYTE editorial staff for their efforts and enthusiasm. ■

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INTEGRATION ON A NEW SCALE

BY DICK POUNTAIN

Wafer-scale integration is starting to yield its first products

In 1984, at the height of his commercial success with home computers, Sir Clive Sinclair launched a pet project in Milton Hall, a converted country mansion not far from Cambridge. The project was called MetaLab, and its intent was to bring together a group of innovative thinkers to work on high-technology projects. Though he hoped the results might eventually redound to the glory of Britain and provide future products for Sinclair Research, MetaLab was not to be tied to schedules; Milton Hall was to become a center for blue-sky research, rather like an English Xerox PARC.

One of the first people to be recruited to MetaLab was Ivor Catt, an electronics engineer and teacher who is a veteran of British electronics, having joined in the heady postwar era when radar and the first digital computers were forging the industry. Catt worked for Ferranti in Manchester in the 1950s, when it was perhaps the world's leading center of computer technology. In the 1960s he worked for Motorola in the U.S. on high-speed logic interconnection and later returned to England to lecture in electronics.

During his long career, Catt arrived at a number of highly unorthodox design ideas and spent many frustrating years trying to get them accepted and implemented. The main strands of his thinking can be summarized as follows: He prefers serial to parallel architectures; he resents the performance penalties that are incurred by conventional chip packaging due to the mismatch of impedance between silicon circuits and printed circuit board tracks; he believes that fault tolerance should be incorporated into computers at the fundamental architectural level, rather than having it added as an afterthought.

Synthesizing all these concerns, Catt came up with a plan for wafer-scale integration (WSI) of semiconductor devices. Wafer-scale integration just means that instead of slicing up the silicon wafers on which chips are made into individual devices and packing them into little plastic beetles, you use the whole wafer with the chips connected on the silicon. Unfortunately, wafers are never perfect because of defects in the silicon, and a proportion of chips do not work. Catt devised a novel serial architecture in which good devices are automatically recognized and connected in a one-dimensional array, while bad devices are locked out in somewhat the same way that an operating system locks out bad sectors on a floppy disk.

In the late 1970s and early 1980s when Catt was trying to sell this idea, corporations like IBM and Trilogy were having spectacularly expensive failures with WSI using conventional architectures, and these botched attempts gave the whole enterprise a bad name. Trilogy tried to get around the problem of bad chips by employing massive redundancy, duplicating and triplicating devices so that they could check each other's operation and produce answers by a majority "vote." Catt pithily summarizes this approach as "soaking the wafer in dollars."

In the late 1970s a team at Burroughs started to work on Catt-style WSI but never went beyond prototype wafers because of a change of management and company politics. After Catt moved to Milton Hall, the survivors of this team, led by Dr. Malcolm Wilkinson, also moved in, and the WSI project finally went ahead, funded by the success of the Sinclair Spectrum.

We now arrive at the present day. Sinclair Research's fortunes have taken a tumble, and its home computer interests, including the Spectrum, have been sold to rival Amstrad. However, a new company called Anamartic Ltd. has been formed to pursue and market WSI devices (the word Anamartic derives, I am told, from the Greek for "without fault"). The general manager of the company is Malcolm Wilkinson, Ivor Catt is adviser to the engineering team, and Sir Clive is a nonexecutive director. The company is temporarily working from Milton Hall, pending a move to new premises, and is looking for second-round funding to go into full production.

THE WISPER 2

The first word of a product from Milton Hall came last year when Sinclair announced that a "solid-state Winchester drive" would be launched for his QL computer. This device never appeared, but its descendant will be the first product from Anamartic Ltd. (Milton Hall, Milton, Cambridge CB4 4AE, England; (0223) 862661).

A solid-state Winchester drive is basically a wafer full of RAM chips connected by a serial access path; to the computer it looks like a serial disk drive, but it has no moving parts and

(continued)

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458.

so is potentially more reliable. A solid-state Winchester drive is also much faster than a magnetic Winchester drive, although slower than ordinary RAM by dint of the serial rather than parallel access.

Anamartic has working samples of a prototype 500K-byte wafer made in NMOS technology. One of these devices, the Wisper 1, is shown in photo 1; the 4-inch wafer is mounted alongside a small peripheral PCB holding the controller and ROMs for the operating software. The first commercial product, to be available in late 1987, will be a second-generation device code-named Wisper 2, which is built on a 5-inch wafer and can hold 7 megabytes. Multiple wafers can be stacked just like Winchester platters and share the same controller, so devices holding multiples of 7 (e.g., 28 megabytes, 70 megabytes) will be made.

The Wisper 2 has the following performance statistics: Its worst-case access time is less than 50 microseconds; its data-transfer rate is 2.5 megabytes per second; and its mean time between failures is more than 100,000 hours (for a 70-megabyte unit). By contrast, a typical Winchester disk has an access time between 30 and 90 milliseconds, a data-transfer rate of around 150K bytes per second, and an MTBF of 25,000 hours, making Wisper 2 about 20 times faster as well as more reliable.

The robustness of the solid-state device should appeal to manufacturers of portable computers and computers that have to work in hostile environments, and the performance of the device is a great improvement over that of conventional disks. However, the economics of silicon fabrication are such that—initially, at any rate—the WSI solution will not compete on price per megabyte with Winchester disks (Anamartic will not reveal any prices, but they are likely to be more than a thousand dollars). Winchester makers with their Far Eastern volume manufacturing plants are currently engaged in a seemingly suicidal price war. Moreover, magnetic storage still has some tricks up its sleeve, like vertical recording techniques that will increase capacity by an order of magnitude at little extra cost.

In the short term, Malcolm Wilkinson sees the market for Wisper among minicomputer and mainframe manufacturers who wish to design disk-caching systems that bridge the gap between fast RAM and disk storage in both price and speed. The arrival of huge optical disks makes Wisper attractive as a high-speed buffer between the slow but cheap disk and fast, relatively expensive RAM. Nevertheless, with Clive Sinclair involved, I shall be very surprised if he doesn't find some way to get Wisper into a personal computer.

Wisper will be fabricated in CMOS technology (although the Catt principles work under any process), and its power requirements are sufficiently low that a battery backup can be used to preserve the contents in case of main power failure. A 70-megabyte Wisper could be kept safe for up to 60 hours by a lithium battery pack.

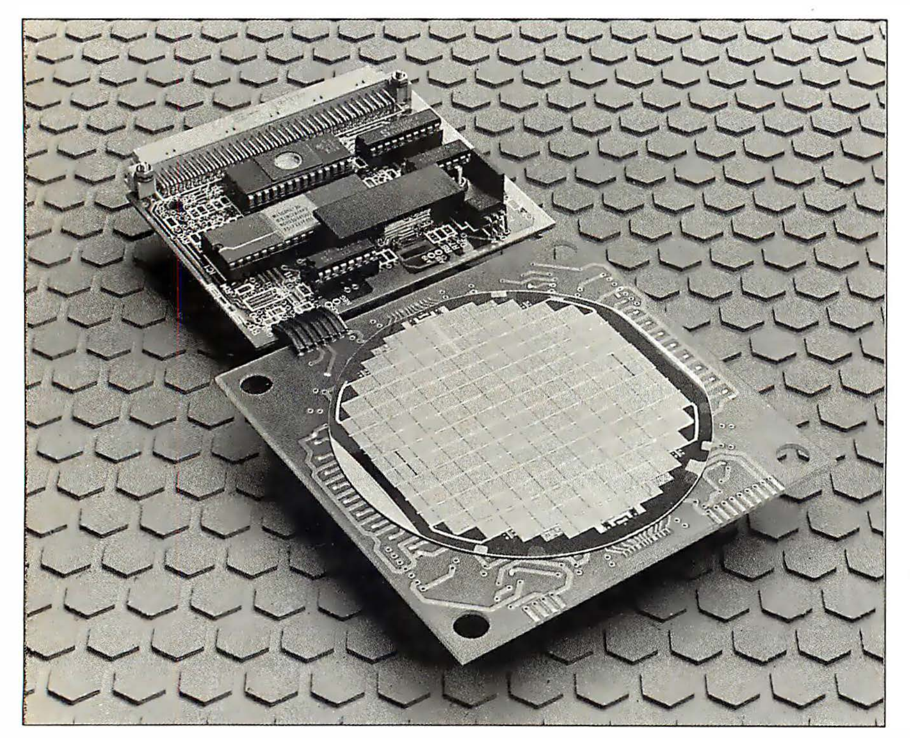


Photo 1: *The Wisper 1, a prototype 500K-byte wafer. The 4-inch wafer is mounted next to a board holding the controller and* ROMs *for the operating software.*

FAULT TOLERANCE

A Wisper wafer contains two main kinds of components. It has a number of conventional RAM arrays, built from standard one-transistor dynamic RAM cells just as if the wafer were going to be cut up into RAM chips. Between these RAM arrays lies a network of serial communication lines, and each RAM chip has a communications node associated with it. A node is connected to its own RAM and to the nodes of each of its four nearest neighbors. Figure 1 depicts a portion of a wafer, showing four nodes and RAM arrays.

When a newly fabricated wafer is to be tested and configured, an initialization program is run that sends signals to the first node. This node then tries to establish connection with each of its neighbors and, if it succeeds, tests them to see if they are fully operational. Control then passes to the next working node, which repeats the process. The algorithm used reminds me of a daft game that used to be popular in Commodore PET BASIC, where a worm finds its way around a maze, exploring each junction with its rapidly wiggling nose. The algorithm ensures that every good node is eventually found and that they end up all connected into a single snakelike path. The initialization program then

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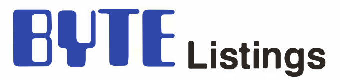


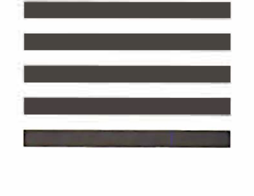
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stores a map of this path.

Having established a path of nodes through the chip, the program walks through the path, testing the RAM arrays themselves, and builds a map of working RAMs. Note that RAMs associated with nonworking nodes cannot be tested as they cannot be on the path; they may be good or bad, but they are forever inaccessible. Typically, up to 30 percent of the devices on a wafer are defective, so 10 megabytes' worth of chips will need to be fitted onto a wafer that is to end up as 7 megabytes. The communications nodes are much smaller than the RAM arrays, so fewer of them will be bad; otherwise, the technique could not work.

The final map of working RAMs and a path that connects them is stored in an EPROM on the controller board. Whenever the Wisper is switched on, software will use this map to connect all the components, which is accomplished in a fraction of a second. There are no fusible links or other permanent connections of any kind. This fact is quite frightening at first, until you realize that floppy and hard disks do exactly the same sort of thing with your files; you have no idea where the bits of a file are stored physically, but the operating system keeps track of them in software. What Anamartic has done is to push the same idea down to the level of physical storage.

The snakelike path through the Wisper is the serial data path by which data is moved to and from the memory. Data and addresses are interleaved and fed serially onto the wafer; they can be separated out again by timing considerations. The RAM arrays themselves, having received an address, work in normal parallel fashion organized by rows and columns. However, data being shifted out of the addressed RAM row remains in serial form and joins the bit stream flowing along the path. This means that access is slower than access to conventional RAM mounted on a parallel bus, and it also means that RAMs at the end of the path will take longer to access than ones at the beginning. The wafer behaves like a disk, even down to emulating head travel.

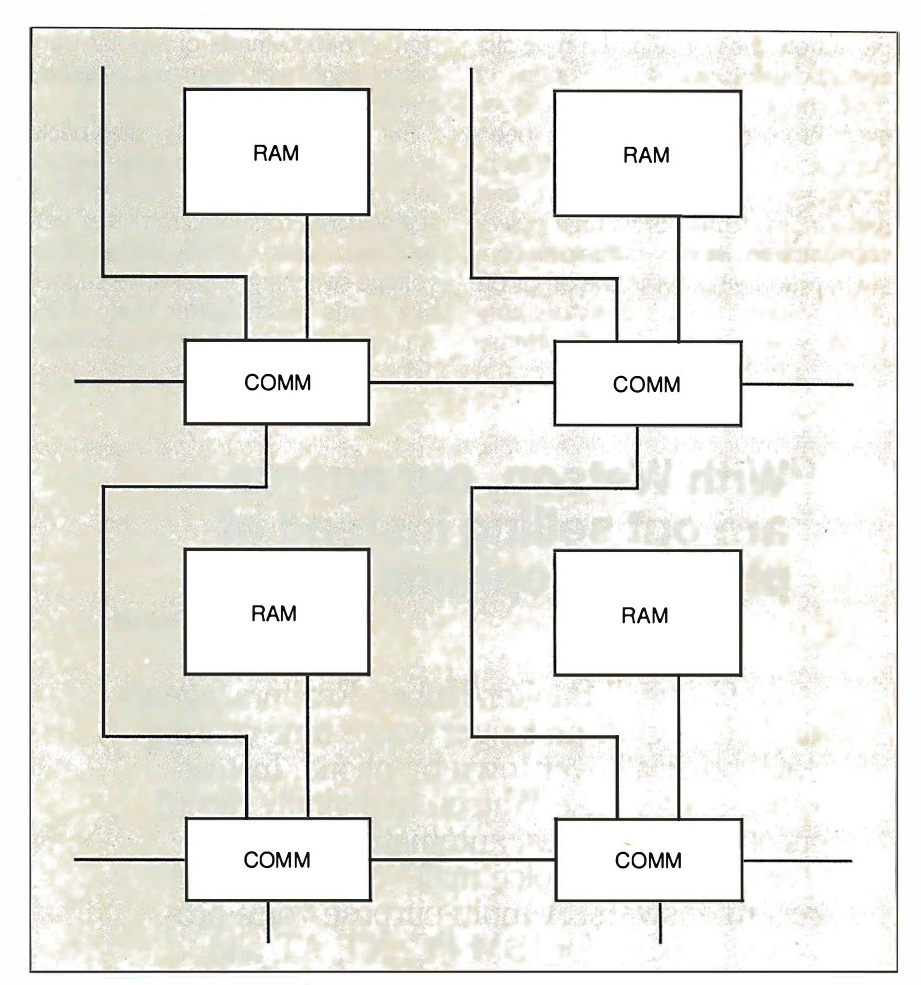


Figure 1: *This diagram shows a portion of a Wisper wafer with four communications nodes and RAM arrays.*

An important consequence of this wholly software-driven approach is that a Wisper can be reconfigured at any point during its life—if, for example, a wayward cosmic ray should knock out a RAM cell. By running the same initialization program and blowing a new EPROM, the device can be made usable again with a slightly reduced capacity.

The Future

It should be clear from the above that Catt's self-correcting technique is not dependent upon the process technology used to fabricate the wafer nor upon the nature of the devices connected to the communications nodes. Exactly the same sort of network could be used to connect an array of multipliers for signal processing, an array of general-purpose processors, or even exotic devices like charge-coupled device light detectors. And the technique could be fabricated in NMOS, CMOS, emitter-coupled logic, or whatever, on silicon or gallium arsenide substrates. The only constraint is that the array must be linear (i.e., one-dimensional). Anamartic intends to capitalize on some of the possible options later, once the Wisper 2 has been established as a product.

A CMOS process was chosen for Wisper 2 because it is easy to get fabricated; all the major silicon houses have invested heavily in CMOS lines in recent years. However, Anamartic is researching a bipolar version of Wisper that offers several advantages. Bipolar technology is as old as the semiconductor technology itself; the original discrete transistors were bipolar devices made from sim-

(continued)

ple sandwiches of p- and n-type silicon. Today, bipolar is still familiar in the form of Schottky TTL parts. However, bipolar technology has been completely supplanted by MOS technologies for microprocessors and memories because of its high power consumption. Bipolar transistors consume power whether in the on or off state, whereas MOS transistors consume power only during the transition. A 68000 made of bipolar transistors might well serve as a programmable cigar lighter.

But apart from this drawback, bipolar technology has some attractive virtues. It is faster than MOS, it scales down to submicron sizes better, and being current- rather than voltage-switching, it can drive capacitive loads much better than MOS. Anamartic's Alan Sinclair (no relation to Sir Clive), in association with the University of Southampton, has devised a novel low-power bipolar RAM cell that will be used in the next generation of WSI devices.

This RAM uses a single-transistor cell based on a silicon control rectifier that occupies little silicon area because it is organized vertically in layers. The bipolar process should be capable of starting at the 1-megabit integration level that conventional RAMs have just reached, but without any need for complex three-dimensional "trench-cell" techniques. Although dynamic, the bipolar RAM behaves almost like a static memory when it is read, producing a high output voltage that does not require amplification (hence saving components), and it has a lax refresh timing. These high voltage levels (together with the layered structure) also make the device quite immune to electronic noise. An added bonus is that it can be fabricated with only 7 masks, compared to 12 for the CMOS process.

This development should improve the cost per megabyte of WSI substantially. With the current Wisper design, there is a cost saving compared to conventional RAM because the wafer does not need to be sliced and packaged, but the silicon cost is exactly the same as for ordinary RAM of the same density. By going to bipolar, Anamartic believes that the silicon cost can be reduced to as little as half that of 1-megabit CMOS RAM.

All these features add up to a faster wafer holding 28 megabytes, at about half the silicon cost of the CMOS version. It will not, however, be ready for production for a couple of years; a demonstration device is planned for late 1987.

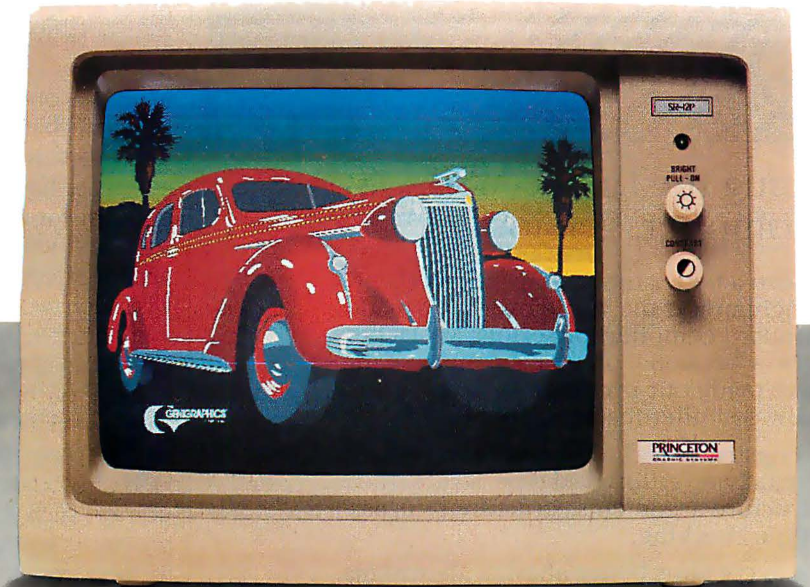
The ability of bipolar devices to drive capacitive loads will be important in image processing, one of Anamartic's future target markets. A wafer-scale array of simple processors, each performing part of a transformation, could be used to process continous streams of video data at high speeds. Bipolar wafers could also be used directly as a video-frame

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store, whereas MOS would need expensive interfaces.

In this sort of application, another feature of WSI becomes important, namely, the low pin-out. Regardless of how many devices it contains, a serial wafer-scale component logically needs only two pins, In and Out (though in practice there are a few more). By contrast, modern microprocessors can have more than a hundred pins, and integrating hundreds of such chips would be a nightmare due to the explosively rising number of pin connections that have to be made. Interestingly, the Inmos Transputer arrived at a solution somewhat similar to WSI. The Transputer uses point-to-point serial connections for transmission of data, although when using off-chip memory, it still requires numerous pins. (It's fascinating to speculate how the Transputer would perform if it were integrated at wafer scale and whether Catt's linear-array approach could be adapted to cope with such two-dimensional networks.)

In principle, Anamartic's technology can be used to build linear arrays of general-purpose microprocessors with on-chip memory to execute parallel programs. However, not every kind of problem is amenable to solution on such a linear array; suitable problems are those that involve performing repetitive processing on a continuous stream of data. It's likely, therefore, that Anamartic will concentrate on small special-purpose processors for transforming the sort of data found in radar and audio and video applications.

I fervently hope that Anamartic can get the financial backing it requires to turn all these ideas into products. The technology looks feasible, and the story has an appealing romantic element in the shape of Ivor Catt's 15-year struggle to get his ideas accepted. However, the City of London is currently feeling sour toward high-technology investment in general, while the failure of Trilogy has unfairly tainted the name of wafer-scale integration inside the industry. At the time of writing (July), though, it seems that Anamartic has the backing to put Wisper 2 into production as a first step along the road. ■

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*hard disk recommended

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C Benchmarks In seconds

	Microsoft C 4.0	Lattice C 3.0	Computer Innovation C 2.3	Aztec C86 3.2	Wizard C 3.0
Sieve of Eratosthenes (register)	82.9	151.4	172.3	88.0	91.9
Copy Block	86.9	231.7	199.0	123.8	189.5

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- Enter in familiar SYMDEB or DEBUG commands.

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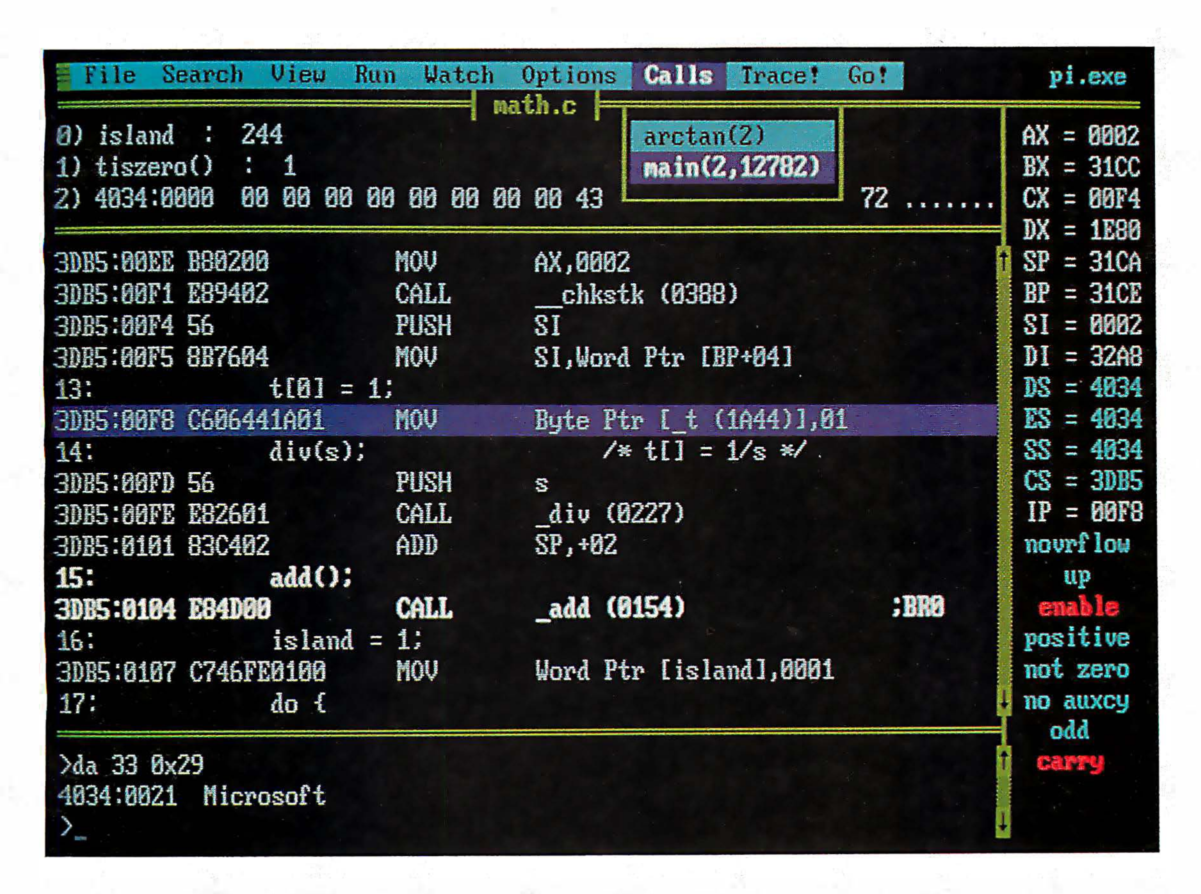
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Resident Headaches

BY EZRA SHAPIRO

Some MS-DOS pop-ups and Microsoft's Works for the Macintosh

It was the Great Crash of '86. I'd loaded seven TSR (terminate and stay resident) programs into RAM and was about to take a break by playing a round of Willy the Worm, a mindless shareware game. I never took that break; I typed "Willy," the screen blanked, and the system locked up. After several unsuccessful resets, I booted the Compaq from a floppy disk and discovered that about half my hard disk's file-allocation table had been turned to mush. Since I had done a backup three weeks earlier (there's another lesson here), it cost me two days of sweat to get the system back to normal. I have no idea what happened, and attempts to duplicate the crash have failed, but I'm forced to wonder about all those pop-ups.

Memory-resident programs for MS-DOS machines are multiplying like mosquitoes in a swamp. It wouldn't be so bad if MS-DOS (or Microsoft or IBM or somebody) offered the necessary facilities and standards to handle pop-up accessories in a straightforward fashion; but no, every developer has to reinvent the technology. As a result, the programs as a class are nasty, ill-tempered beasts that cause as many problems as they attempt to solve. Trying to evaluate them, I've learned a frightening rule: The more memory-resident programs you use, the more likely you are to freeze your software, crash your system, or lose your data.

While my testing has been neither faultlessly scientific nor absolutely comprehensive, it has certainly been valid in terms of the real world. My system is cleaner than 95 percent of the systems you'll find; even though every stand-alone application runs without a hitch (i.e., if it's going to run at all on any machine), I have experienced every possible software disaster while playing with memory-resident programs.

Thus, it's impossible for me to say whether any specific program is truly safe to use; there are just too many variables to track: foreground applications, other pop-ups, versions of the operating system, etc., etc., etc. Everything interferes with everything else. So you're on your own when experimenting with the TSR programs mentioned below. (Good luck.)

Here are a few general guidelines. Don't load your system with more than one or two TSRs that are vital to the way you work; add a third or fourth and the odds of failure increase astronomically. Don't believe manufacturers' claims of universal compatibility; it's not possible, given the state of the art. Finally, expect to be disappointed.

For this column, I've pulled four TSR programs out of my growing pile of them. In the next few months, I'll try to get to as many of the others as makes sense.

Cursor Madness

Of this month's products, I'm happiest with **Cruise Control** (Revolution, $29.95), but I'm irritated that I need it.

Ever lean on a cursor key for a second and then watch in horror as the cursor sails across your screen to a spot well beyond where you wanted it to stop? Cruise Control is the answer. It makes your cursor *behave.*

For a small utility, its list of features is impressive. You can adjust cursor speed to your taste, anywhere from a painful crawl to a whizzing blur. With "antiskid braking," the cursor stops instantly when you lift your finger from a key—no more cursor run-on. You can have any key repeat automatically (at a reasonable rate) until you touch another. Revolution also throws in single-keystroke time and date stamps and a screen-blanking function to protect your monitor.

Cruise Control offers a selection of four strategies: one for most standard programs, a second for programs that set up their own internal keyboard buffers, a third for ported CP/M applications, and a fourth specifically for WordStar. It should run with just about anything.

I've used it extensively, mostly with Framework and a patched copy of WordStar for the PCjr, and it's delightful.

The reason I'm irritated about needing this program is because it does something I think the operating system should do. Dear old MS-DOS is caught with its pants down on this one.

TSR Teamwork

Next is **Referee** (Persoft, $79.95), a group of three programs designed to simplify using TSRs. The ideas behind the product are really quite good, but I suspect the company may have taken on an impossible mission.

Referee lets you determine which memory-resident programs are active at any given moment. You tell it which TSRs you want running when you're using a particular piece of software,

(continued)

Ezra Shapiro is a consulting editor for BYTE. *Contact him at* P.O. Box 170040, *San Francisco,* CA 94117-0040.

PopDrop lets you unload TSRs from RAM without rebooting.

and it disables the others.

Let's say you want to have SideKick and ProKey available when you're at the DOS prompt, Ready! and Graph-in-the-Box in your spreadsheet, and Ready! and Strike in your word processor. First, you run a stand-alone program called REFEREE and give it lists of your applications and pop-ups. Next, you specify sets of TSRs for your applications. Persoft has done this part well; you can set up your combinations (what Persoft calls "RAM teams") in less than five minutes.

A second component, REFWATCH, is a TSR you load before any other memory-resident tools. REFWATCH monitors the DOS command line and determines which TSRs should be activated or deactivated based on the information collected by REFEREE. The final program, SIDELINE, is a TSR that gives you a status check and allows you to enable or disable pop-ups from within your application.

In theory, then, you've got control over your TSR software. You can use what you want when you want it, and you can avoid conflicts between programs that use the same hot keys. However, in the absence of standards, you wind up with two more resident programs in the stack (REFWATCH and SIDELINE), and that means potential compatibility headaches.

Several of us at BYTE got copies of the product when it was released. I couldn't get it to work with Instant Recall, and my system froze every time I tried to use SIDELINE. Jon Edwards had no problems with SIDELINE, but he discovered that SuperKey could no longer communicate with SideKick. Then Dave Haskin at Persoft called to say that Cruise Control was incompatible with Referee but was being fixed.

I like the crew at Persoft; they're organized, professional, and competent. When they say they intend to work their tails off to solve the compatibility problems, I believe them. I don't doubt that they'll get the program working smoothly with all the major pop-ups, and if that's what you want to run, Referee will be a great program for you. But there will always be a few obscure old programs and a couple of unorthodox new ones that will refuse to work with Referee, at least in its current form. If you tend to experiment, frustration lies ahead.

ANOTHER METHOD

PopDrop (InfoStructures, $19.95) takes a less sophisticated approach to the question. It's merely a utility that lets you unload TSRs from RAM without rebooting your system, either one at a time or all at once.

In operation, it's a lot like the TurboPower Software TSRCOM utilities I wrote about last month. Unlike TSRCOM, a group of small public domain programs, PopDrop is a single piece of software, and as such is slightly easier to use.

Each time you invoke PopDrop, it places a small marker in RAM, allowing you to create layers of pop-ups between the markers. A second command clears out memory up to (or including) one or all of the markers. PopDrop also has a View command that shows you a map of memory, so you can tell which TSRs you've loaded. This strategy seems to work in most cases; the only problems I've had with either PopDrop or TSRCOM have been with very sensitive TSRs. The choice between the two is a coin flip; if you're more comfortable with commercial software, buy PopDrop. It works.

ELECTRONIC STICKERS

SmartNotes (Personics, $79.95) is a good idea that's only slightly flawed in its execution. This TSR program provides a way to attach marginal notes to files; if you've scrawled comments on those little yellow sticky tags

(continued)

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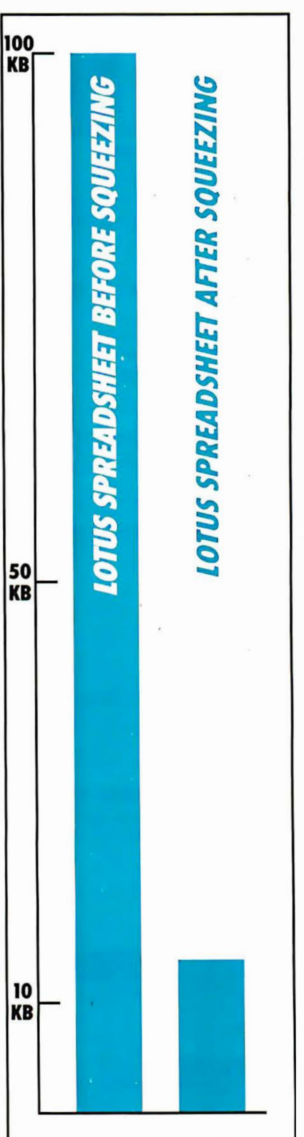
Spreadsheets are wonderful tools, but they have three major drawbacks: they take up a lot of disk space, they take a lot of time to load and to save, and they're expensive to send electronically.

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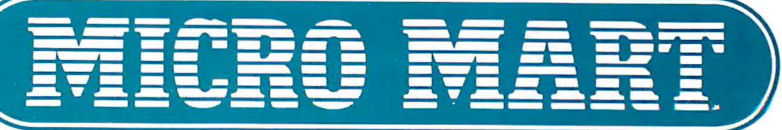
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and stuck them to manuscripts or reports or walls, you've got the basic concept.

SmartNotes generates the equivalent of those stickers, in two sizes (5 lines by 23 characters and 10 lines at the same width) and half a dozen colors. The program attaches notes to text or spreadsheet cells by "remembering" the appearance of the relevant chunk of the screen; it's a form of pattern matching. Thus, not only can you annotate within an application, you can even add comments to your directory listings. Storage files can hold 50 notes, and they are completely independent of application-generated files.

I can see SmartNotes as the perfect product for any office where people must comment on a document before producing a final draft. This is the best way yet to suggest changes without having to alter an original.

Now for the quibbles. In all of Personics' promotional screen shots, notes are *always* attached to items to their left. It looks great because there's a little arrow in the upper left corner of each note calling attention to the flagged data. Unfortunately, that arrow is merely decoration—it's always there, pointing to the left, even if you're flagging an item to the right. This may seem like a trivial gripe, but it can get quite distracting.

Also, though the note editor is rudimentary, it does include word wrap. With a 23-character maximum width, word wrap is a lot more trouble than it's worth. I wish there were some way to shut it off.

Conclusion? SmartNotes is handy, particularly for team projects. Its flaws are easy to live with, the documentation is excellent, and the program is a breeze to run.

IN THE MAC CORNER

I'd call Works (Microsoft, $295) for the Macintosh a wonderful piece of software if I could figure out the rationale behind its design. The product is a four-in-one integrated package that combines a word processor, a spreadsheet, a database manager, and a simple communications module. It will link databases and documents for an

(continued)

uncomplicated mail merge, turn spreadsheets and databases into good-looking business graphs, and spit out classy documents and database reports. Everything is clearly defined, true to the Mac interface, and professionally executed. Mac users will be particularly pleased to see that text does not lose attributes when moved between applications (an annoyance when you use the Mac's Clipboard with stand-alone programs).

In fact, I'd say that Works is perfect for 90 percent of what anybody does with a computer. But it *is* limited, and that's why I have my doubts. None of the individual pieces is as strong as other nonintegrated products, so I find myself coming up with a series of qualified recommendations.

Works is an excellent solution if your primary computer use is in an area outside the Big Four. If you use your Mac for programming, or graphic design, or something arcane, the package represents a good way to solve your basic writing and data-handling needs for less than you'd spend on stand-alones. And because the product is integrated, you don't have to mess with Switcher to have multiple functions loaded at the same time. I suppose this also means that Works would be terrific for first-time users and for businesses that don't have heavy-duty demands.

If you think you'd place heavy demands on one of Works' components, though, I'd recommend that you purchase a full-power product in that category. Whether you should buy Works to give you the other components is up to you; I don't have strong feelings either way at this level. On the other hand, if you need power in two or more of Works' categories, you'd be wasting your money if you bought it.

This program would be a knockout at $100; at $200 it would still be pretty nice. At nearly $300, I find myself scratching my head about it; the same money could buy three top-grade programs for word processing, communications, and database management that would make Works look sick.

One final thing about the product

(continued)

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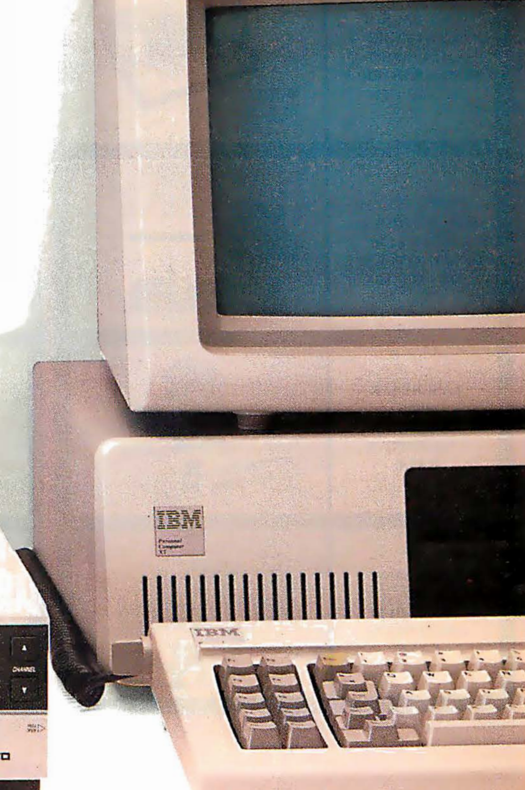
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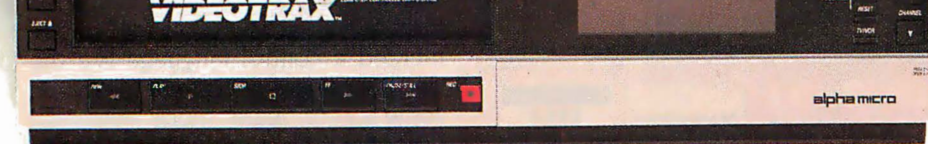
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PARADOXES OF PROBABILITY

BY ROBERT T. KUROSAKA

A survey of sucker bets and an analysis of how they work

Nonintuitive probabilities are all around us, leading to a proliferation of so-called sucker bets. In this column, I'll analyze some of the more popular ones and simulate a couple of them with BASIC computer programs.

How about a small, friendly bet? Four playing cards, two red and two black, lie facedown on the table. Without looking, you choose any two cards. I'll bet you $1 that you pick one red card and one black card. Shall we play?

Since you hesitate, I'll explain the natural fairness of this game. Only two outcomes are possible: the colors match or they do not. Your probability of winning is therefore one-half. The game is fair since neither of us has an advantage. Ready to put your money down?

You won't be fooled that easily, right? Your sense of caution is admirable. I'll explain further. Three, not two, outcomes are possible: Both cards you select are red, both are black, or one is black and the other red. The colors match in two of the three cases. Thus, your probability of winning is two-thirds. The game is in your favor. Now will you play?

Your suspicious nature is beginning to annoy me. Very well, here is my final explanation. Four (count 'em, four) possibilities exist. Consider that the cards are chosen one at a time. Both cards could be red; both could be black; the first red, the second black; or the first black and the second red. The colors match in two of these four possible drawing sequences, giving you (again) a 50-50 chance of winning the bet.

Okay, I've listed all possible outcomes in three different analyses, and in every case, your chances of winning the wager are 50-50 or better. So how about that friendly bet?

Did you accept the bet? If so, you have just been hustled.

Examine your chances more closely. When you choose the first card, it must be either red or black; the choice has no effect on your chances of winning. Now, of the remaining three cards, how many match the color of the card in your hand? Only one. Therefore, your probability of winning is only one-third (honest, this time!).

So what is wrong with the three previous analyses? To varying degrees, each of them is based on an incomplete listing of all possible outcomes. The incompleteness is subtle and therein lies the hustle.

Denote the four cards as r_1, r_2, b_1, and b_2. List all possible pairs of cards you can choose: (r_1,r_2), (r_1,b_1), (r_1,b_2), (r_2,b_1), (r_2,b_2), (b_1,b_2). Of the six possible outcomes, only two have matching colors. Your probability of winning is indeed one-third.

PHONE BOOK FOLLIES

Open a telephone book to any page and select any column. In that column, circle any 13 consecutive phone numbers. I will bet $1 that at least two of the phone numbers end in the same two-digit number.

You may feel more confident about making this wager. After all, there are 100 possible two-digit numbers from 00 to 99. Thus, the probability of an exact match would seem to be 1 in 100. Even with 13 chances, it would seem unlikely to find a pair of matching two-digit numbers. But again, intuition betrays us.

The sucker in this bet favors the possibility that no match exists among the 13 phone numbers. Let's analyze the probabilities of that happening. The first number on the list can be any two-digit number and has no effect on the odds. The second number must not match the first; therefore, it must be one of the other 99 two-digit values; that probability is 99/100. The third number cannot match either of the first two numbers, leaving it 98 possible nonmatching numbers; that probability is 98/100.

The pattern continues down to the thirteenth number, for which only 88 possibilities exist (the other 12 having been taken already); its probability for not matching is 88/100.

The probability that no match exists among the 13 numbers is the product of the individual chance factors:

$$\frac{99}{100}\times\frac{98}{100}\times\frac{97}{100}\times\cdots\times\frac{88}{100}\approx 0.442775$$

That is, you can expect to win your bet (no match) about 44.3 percent of the time, and I can expect to win the other 55.7 percent of the time. Simplifying it, my odds of winning are about 5/9. For a truly fair game, I should offer odds: my $5 against your $4, or $1.25 against your $1. Since our original bet was even money (1:1), I have a definite advantage. In 1000 such wagers, I can look forward to winning $557 and losing $443, showing a profit of $114.

Altering the conditions so that you circle 20 numbers increases the probability of a match to 87 percent; 30

(continued)

Robert T. Kurosaka teaches mathematics in the Massachusetts State College system. He can be reached c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

Listing 1: A BASIC *program to illustrate the phone book bet and similar wagers. An abbreviated sample run is also shown.*

```
10 OK=.99999          :REM Close enough to 1
20 PRINT "Calculate the probabilities for finding a
   match,"
30 PRINT "given C possible outcomes and taking N events."
40 INPUT "Enter value for C (>1)";C
50 IF C<2 THEN PRINT "Can't be.": END
60 PRINT "Enter a starting value for N, from 2 to ";C-1;
70 INPUT SV
80 IF SV<2 OR SV>=C THEN PRINT "Can't be.":END
90 PRINT "Table of probabilities given ";C;"possible
   outcomes."
100 PRINT "# of events    Probability"
110 FM$=  " ######          #.######"
120 FOR N=SV TO C-1
130 P=1
140 FOR J=1 TO N-1 STEP 1
150 P=P*(C-J)/C
160 NEXT J
170 PRINT USING FM$;N,1-P
180 IF 1-P>=OK THEN N=C-1
190 NEXT N



Calculate the probabilities for finding a match,
given C possible outcomes and taking N events.
Enter value for C (>1)? 100
Enter a starting value for N, from 2 to  99 ? 10
Table of probabilities given  100 possible outcomes.

# of events     Probability
      10          0.371843
      11          0.434659
      12          0.496847
      13          0.557225
             . . . .
      41          0.999933
      42          0.999960
      43          0.999977
      44          0.999987
      45          0.999993
```

numbers gives a match probability of more than 99 percent.

Extending the bet to cover three-digit numbers gives results that are even more surprising. Circling only 38 numbers, the probability of finding a three-digit match is more than 50 percent; circling 70 numbers gives a probability of 90 percent that you will find at least one pair of matching three-digit numbers.

The familiar "Birthday Paradox" has a similar explanation in the laws of probability. Given a gathering of 23 people, the odds that at least two people share the same birthday (month and day) are, surprisingly, better than even (50.7 percent). For 24 people, the probability rises to 53.8 percent. With 41 people, the chance rises to 90.3 percent.

The paradox evaporates when we analyze the situation closely. For simplicity, we exclude February 29 birthdays and assume that birthdays are uniformly distributed among all 365 days in a year. That is, the probability of one's birthday falling on a particular date is exactly 1/365. The probability of two people *not* sharing a birthday is thus 364/365. Each additional person we consider adds another reducing factor to the probability that no birthdays are shared.

The program in listing 1 lets you explore the probability trends for this general class of sucker bets. You specify the number of possible outcomes; the program shows the probability of a duplicate outcome occurring within a specified number of events.

Card Games

Another class of sucker bets involves playing cards. Here's one of my favorites.

Two shuffled decks are on the table. I bet that among the first six cards in each deck are two identical cards. Your bet, if you choose to accept it, is that no duplicate cards will be found among the first six cards in the two decks. What are your odds?

We draw the first six cards from deck 1. In deck 2, the top card cannot be any of the previously drawn six cards; it must be one of the other 46 cards. The probability of a nonmatch is thus 46/52. The second card must not be any of the six noted cards; it must be one of the other 45 cards of the 51 remaining in deck 2. The probability of a nonmatch is 45/51. The pattern continues for the remaining four cards, giving a cumulative probability of

$$\frac{46}{52}\times\frac{45}{51}\times\frac{44}{50}\times\cdots\times\frac{41}{47} \approx 0.4600933$$

Probability of a nonmatch after drawing six cards is about 46 percent, leaving a probability that a match will be drawn of about 54 percent (certainly enough for me to make a living on, if I can find enough suckers to take the bet).

Now suppose we have three shuffled decks on the table. I bet that among the top four cards of each deck will be found two identical cards. You bet that no matches will be found. Are your odds any better this time?

After drawing four cards from deck 1, the odds of not finding a match in four cards from deck 2 are, respectively, 48/52, 47/51, 46/50, and 45/49.

Drawing from deck 3, the first card cannot be any of the eight previously drawn cards; probability of that is 44/52. Probabilities for the next three cards not matching are 43/51, 42/50, and 41/49.

Multiplying the probabilities gives a

(continued)

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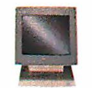
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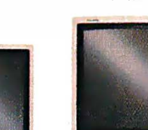
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Listing 2: A BASIC *program to simulate a class of bets involving two or more card decks. A sample run is included.*

```
10 PRINT "Given D decks, each containing N cards,"
20 PRINT "this program calculates the probability"
30 PRINT "of finding at least two identical cards"
40 PRINT "among the top C cards of each deck."
50 PRINT
60 INPUT "How many decks (>1)";D
70 IF D<2 THEN END
80 INPUT "How many cards in each deck (>0)";N
90 IF N<1 THEN END
100 PRINT "Draw how many cards from each deck (1-";N;")";
110 INPUT C
120 IF C<1 OR C>N THEN END
130 PRINT "Successive chances for NOT matching..."
140 P=1
150 FOR J=1 TO D-1
160 FOR I=1 TO C
170 X=N+1-J*C-I
180 Y=N+1-I
190 PRINT USING "### / ### = #.#####";X,Y,X/Y
200 P=P*X/Y
210 IF P=0 THEN I=C: J=D-1
220 NEXT I,J
230 PRINT "Cumulative probability of a MATCH=";1-P

Given D decks, each containing N cards,
this program calculates the probability
of finding at least two identical cards
among the top C cards of each deck.

How many decks (>1)? 3
How many cards in each deck (>0)? 52
Draw how many cards from each deck (1- 52 )? 4
Successive chances for NOT matching...
 48 /  52 = 0.92308
 47 /  51 = 0.92157
 46 /  50 = 0.92000
 45 /  49 = 0.91837
 44 /  52 = 0.84615
 43 /  51 = 0.84314
 42 /  50 = 0.84000
 41 /  49 = 0.83673
Cumulative probability of a MATCH= .6396003
```

cumulative probability for not finding a match of 0.3603997, or about 36 percent. My chances for winning the bet are thus around 64 percent. I can live like a king on that.

The program in listing 2 calculates the odds for the general condition using d decks, n cards in each deck, and drawing c cards from each deck.

A Poker Challenge

An unusual wager—which, alas, is not so easy to model with a computer program—involves some knowledge of the game of poker. Take any 25 cards from a shuffled deck. I bet I can form five poker hands that are as good as a straight or better: a straight (five cards in sequence), a flush (five cards of the same suit), a full house (a three-of-a-kind and a pair), a four-of-a-kind, or a straight flush (five cards of the same suit in sequence).

I don't know the exact probability of success, but it is evidently very high, contrary to common sense. Try the game yourself, and you will be surprised at how seldom you fail. Think about ways to model the situation with a computer program. (Hint: Try sorting the cards first by suits; two flushes will always be found. Then look for a straight or a full house.)

I would be delighted to hear reports of your investigations into these and other sucker bets. ■

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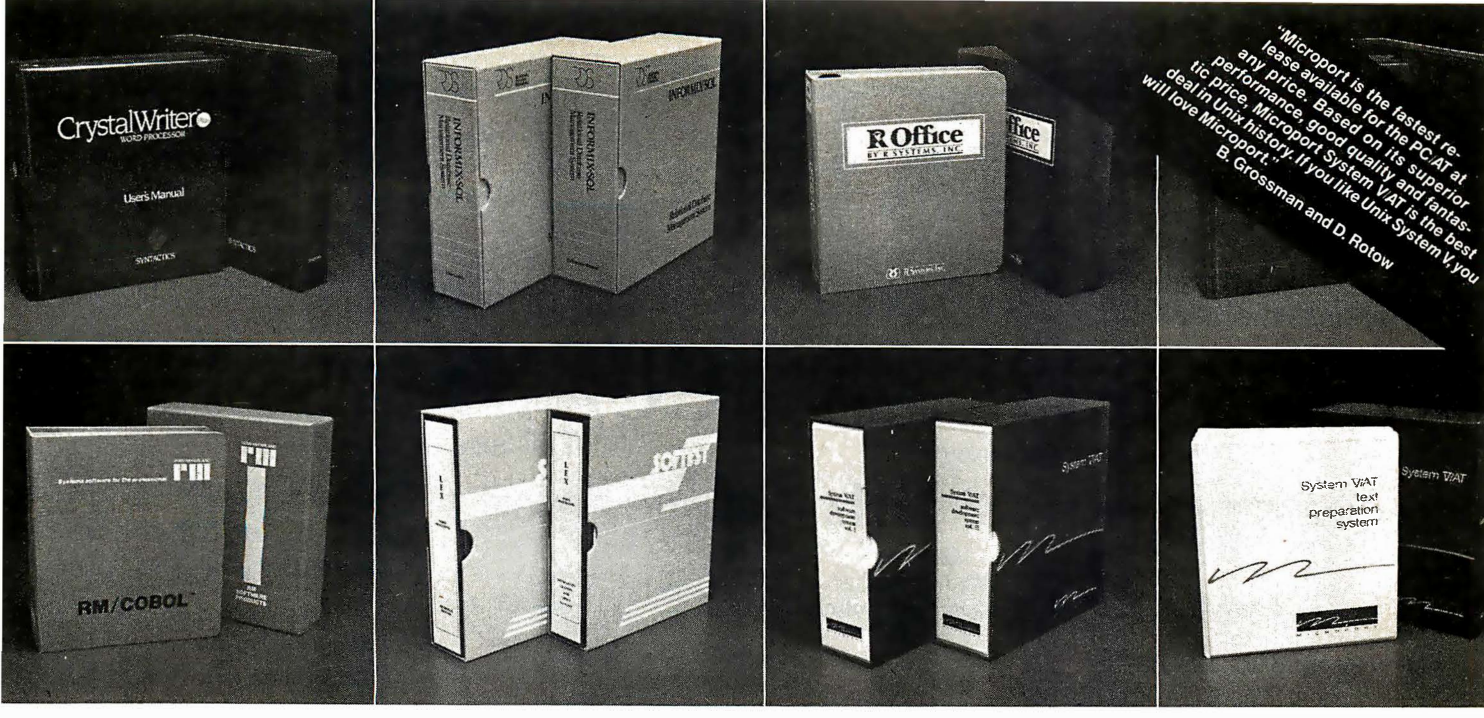
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from Microport. This package consists of the complete System V, Release 2 Documenter's Workbench (DWB), and includes both the new troff and the old troff. Drivers for the HP Laser Jet Printer and Apple's LaserWriter are also available.

These are but a few of our available packages. Virtually everything listed in AT&T's catalog can now, or will soon run with our operating system.

Regarding Our SYSTEM V operating system.

More than a look-alike, Microport's System V complies with AT&T's new binary standard and was derived from AT&T's own UNIX System V, Release 2 iAPX286. It thereby contains standard System V features the competitors don't support, such as the powerful symbolic debugger (SDB), the shell-layering job-control facility and the F77 Fortran compiler, as well as programming tools such as ctrace, cflow and bs. Over 200 utilities come standard to let you search and modify files, make use of electronic mail, calculate electronically, convert data and publish.

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M I C R O P O R T

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Scotts Valley, CA 95066
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Inquiry 215

Conducted by Jerry Pournelle

GAVILAN USERS GROUP

Dear Jerry,

I am writing in reply to a letter in your April column ("Gavilan Information, Anyone?" page 302).

Yes, there is Gavilan Portable Computer support. The Gavilan User Group and Gavilan Service Repair Center continue to profit from the fall of the Gavilan company. We number about 1500 owners throughout the world and we support our computer without company or retail assistance.

Persons wishing information on the Gavilan Portable can write or call

ROBERT W. BROWN
780 Manx Ave.
Campbell, CA 95008
(408) 379-2774

Glad to hear it. Gavilan was a pretty good machine. I very nearly bought one at surplus, but then I wondered what I would do with it. I can hardly write a lot about orphans!—Jerry

LAPTOP COMPUTERS

Dear Jerry,

I read the section "Traveling" in your July column with great interest. I am glad you are finally saying something about the power of small laptop systems. I have been using a Model 100–based system for home computing since March 1983, and I rarely need to use any other. (It also mates well with my Tandy 2000 at work.)

When I bought "Angus," I was looking for a replacement for my 48K TRS-80 Model I. I had originally intended to get an Osborne when I started shopping, but the laptop use of the Model 100 won out in the end. That Model 100 was one of the first on the market.

As soon as I could contact Larry Holmes, I added 8K to bring RAM to 32K. In early 1984 I added one of the early Holmes Engineering's Chipmunk 3½-inch disk drives, and this past Christmas I added Personal Computer Support Group's Super ROM.

The NEC-based system that you prefer for traveling is good. However, the lack of the Chipmunk and Super ROM make it less than it could be. Both the Tandy Disk Drive and Brother FB-100 store only 100K each under TS-DOS and must use the RS-232C port. The data transfer rate is limited to 9600 baud. Since it is a serially accessed device, random access of the disk files is *not* possible, and file size is generally limited by the available free RAM.

On the other hand, the Chipmunk stores 360K, connects directly to the Model 100's main bus, and supports true random access of the disk files, which can be up to the full capacity of the disk.

Traveling Software's Ultimate ROM II is one of the best—but only a close second to PCSG's Super ROM. Lucid is a *much* better spreadsheet, and Write ROM is about the best formatter on the market. The Lucid-Data extension is, above all else, easy to use. Lastly, PCSG's outliner Thought is better than either ThinkTank or Idea.

WAYNE H. THOMPSON
Weatherford, OK

Thanks. I'm not familiar with the Chipmunk or PCSG systems. Certainly 360K and full file access would be preferable to the TS-DOS system I have, but for me LAPDOS gets the job done. Does the PCSG Super ROM give me 60-character lines? I find that once I have gotten used to having that much information on the screen I hate to go back to 40 characters. —Jerry

Dear Jerry,

My introduction to BYTE and your writings began in January 1984 at the time of my first Radio Shack Model 100 purchase. Since then, I've acquired many more Model 100s and several PC-class machines for use in our business. Because I entered the revolution at this lower level I've formed a slightly different perspective than you have about the utility and role of microcomputer equipment. Simply stated: "If you can finish the work on the Model 100, don't start it on a PC."

This concept may be a derivative of Occam's razor or perhaps a first-user, first-machine rationalization. Either way, by entension, the PC is used like a mainframe for large files, routine batch jobs, or jobs requiring graphic output.

I've noted with interest the creeping utility of the NEC 8201 in both your own and your wife's work and recognize that you are now lined up to hit the "great organizational brick wall."

There you are in some foreign airport with two pounds of SideKick printout and four pounds of computer that contains the built-in application software for telephone and appointment management, but without the necessary RAM files. It's a perfect picture of the brick wall: static paper files coupled with empty, but dynamic, management tools together taking twice the space and weight required.

It's not a pretty picture, but now that it is clear, the solution is obvious. Others have been here before you. With all due respect to Mr. Kahn, dump SideKick. Give Big Kat a rest. Put the NEC or the Model 100 on your desk. Use it all the time for appointments, phone calls, and electronic mail. Liberate yourself. Take the unit and a phone extension cord with you to your deck or yard on clear days and take it on all your trips. You will soon wonder why you put up with being anchored to your PC work area.

Now that you have mastered some of the techniques for moving files back and forth between the different machines, you can afford to dedicate some Model 100 RAM space to your phone numbers, log-on strings, appointments, due dates, expense details, received messages to review, pending messages to send next, and notes of all kind. This may still leave room for a normal day's output on your next novel.

The slim cursor keys on the Model 100 are compensated for by a convenient set of control-key combinations. I understand this set has roots going back to Electric Pencil, so you may already know them from other word-processing software you have used. They are listed in the Model 100 Owner's Manual together with others equivalent to the TEXT function keys and the command keys. Combined, these allow all operations except Paste from the keyboard.

Without comparative experience I would think that the Model 100's built-in modem (no extra cost) and TELCOM in ROM is a more convenient, economic, and reliable combination than the separate modem and RAM-based communication software in the NEC.

The Tandy 102 has replaced the Radio Shack Model 100. It's a half-inch thinner and weighs a pound less, probably in line with your new binder.

(continued)

Thankfully, airports now have pay phones that accept the direct-connect cable, which is much simpler to use than juggling the acoustic cups in a small space. I wonder if Tandy had anything to do with this important improvement?

Thanks for all the tips and entertainment. The Fact Cruncher demo was impressive and we have received the operating version for implementation in writing repair procedures.

TED MACKAY
San Diego, CA

You tempt me. You are not the only reader who uses a small laptop as the "only" computer.

I don't print out two pounds of SideKick. I do print out the calendar, year, month, week, and one for each day I'll be on my trip. Since I carry my shoulder bag with a logbook in it, adding a dozen sheets of paper is no problem. I haven't yet developed the habit of carrying the laptop everywhere, including to appointments and lunch. Perhaps I should. Certainly a number of readers do.

As to liberating myself from my present workstation, I think you have the wrong idea. I like it here in my cockpit surrounded by computers. Just at the moment I've got a hot game of Space Pirates going on Big Kat; just try that on your lapboard machine!—Jerry

UCSD PASCAL

Dear Jerry,

UCSD Pascal was great for its time and even has a few things going for it today. It is very compact in p-code form and fits small micro systems like Apple II and Commodore 64 well. It is also extremely portable without hardware additions. I work in educational software and we write *big* programs completely portable to Apple, C-64, and IBM; just different assembly routines in libraries. In a couple of weeks (no kidding!) we could port all our applications to any major microcomputer our market demanded. Even the assembler syntax is standard across systems. Tons of segments, concurrency, strings, floats, and native code generation. UCSD is no slouch even today and supports a good number of languages. Have a look at the Pecan power system. It's not the be-all and end-all but it has no apologies to make to CP/M.

How come BYTE never liked the TI-99? It has a beautiful machine language, solid construction, nice BASIC, speech, sprites, device-independent I/O, etc. It has some shortcomings, just like everything else, but it was a pretty good machine, far better in all respects than the C-64, which came out three years later. I just don't think it got a fair shake in BYTE.

I am running a 1040ST at home and will make do until something with a 68020 and 4 or 8 megabytes gets cheaper. I see Atari doing for systems what Borland did for software—putting a realistic price on a quality product and driving the rest of the industry in a similar direction.

TONY A. G. BIGRAS
Victoria, B.C., Canada

I found UCSD Pascal hard to use, but I've always been quick to say that many people I respect disagree with me; and, of course, I much liked the Sage II computer, which used p-System as its operating system. As to whether p-System has any apologies to make to CP/M or vice versa, that, alas, is probably moot.

I don't know about BYTE, but I never cared much for the TI-99, in part because TI in those days was careful to tell all the hackers to drop dead. They wanted it kept a dark secret what was going on in their machines. They accomplished that goal.

I think you might be right on the money in your thinking about Atari. The Atari ST has as much bang for the buck as any computer around.—Jerry

ON YOUR OWN

Dear Jerry,

I am writing to you to let off a little steam about the American attitude toward the rest of the world. I do not expect you will agree with the views I express here because you are an American, but I decided to write anyway. The views expressed are purely my own but I know many of my colleagues feel the same way.

The first point is more general than the second and affects many British companies.

Several years ago, we bought a 68000 single-board computer from a company called Forward Technology Inc. It looked pretty good from the advertisement. When it arrived it was accompanied by a "Preliminary Manual," with the promise of a proper manual later. This manual was definitely a first attempt and there was a lot of information that was either missing or incorrect. Unfortunately, we did not know this at the time. After about two years, the project was abandoned and the board was put to one side. We had still not received the real manual and our letters and requests for information were all ignored.

In a recent clear-out of junk in the stock room I was given the board. My letters to Forward Technology were also ignored. I have found out a lot about the board by disassembling the monitor, getting data sheets on the chips, and tracing tracks. It has been a long, hard struggle but I have found out that the board would have been suitable for the project it was originally intended for. The hardware is superb, but the firmware is awful, and the documentation is even worse. What a waste of money (the board was very expensive). The project was abandoned for the lack of a little information that Forward Technology already had. The attitude of this firm seems to be "We are happy to sell you the product, but after that you're on your own."

At work we have replaced our main computer system twice recently, once by choice, once by necessity. The first replacement came about because we wanted to replace an old minicomputer with something bigger and better. We bought a 68000 system from a company called Wicat Systems Inc. (an American company). What a disaster it was! The operating system seemed to be only half-written. After months of argument and many revisions of the software, we abandoned it. The attitude of this firm seems to be "We are happy to sell you the product, but after that you're on your own." This system was replaced by several computers from the firm Research Machines (a British company) and we have been very satisfied with them. They are always willing to help with information and software. What a difference.

These are just two examples. There are many others, but I am writing a letter, not a novel. For any new equipment our policy is now to buy British or Japanese. Although this policy may be more expensive, there are benefits that outweigh the expense.

The second point is that the U.S. government restrictions on the sale of high-technology products to Eastern Bloc countries are having an adverse effect on many British companies. A British exporter now needs two licenses—one from Whitehall and one from the United States—to sell anything outside the country.

I am not complaining about the aims of these regulations. I do not wish to sell equipment to Eastern Bloc countries. I am complaining about the way these regulations have been set up to give an unfair trading advantage to American firms.

The current export licensing regulations imposed by the U.S. government have brought an intolerable burden to bear on British companies trading in high-technology products of U.S. origin or British-made goods that include even the smallest proportion of U.S. components.

When initially made aware of the ex-

istence of these regulations, many people find it astonishing that British companies are being forced to comply even though not bound to do so by British law. The reason for this is simple: noncompliance rapidly leads to "blacklisting" and subsequent loss of supply of the products. So, once the British exporter has resigned himself to being bound by U.S. law and has set about applying for the necessary reexport approval from the U.S. Department of Commerce in Washington, DC, in respect of each and every export contract, he finds that his troubles have only just begun.

It is not just a question of filling out a form, sending it off, and receiving the necessary license a few days later, as we are accustomed to in the majority of cases when applying to our own department of trade in London. Filing the application with Washington is merely the beginning of a long and tedious trail of queries, referrals, and delays.

Should Washington not have a file on the nominated end user of the goods, then an interminable system of enquiry through the local U.S. embassy ensues. At best, an individual license application is granted only after several weeks. At worst, months may elapse, resulting only too often in the frustrated cancellation by the customer and the ending of a valuable customer relationship, which may have taken months to build. Speed of delivery is one of the foremost advantages when competing for orders. How can British companies hope to survive in the disastrous climate of bureaucracy and delays, which affords massive advantages to competititors, both in America and in all other countries, where no restrictions are in operation at all? American companies can export directly from the U.S. under a general license and without any need to make individual applications for each contract. Clearly, the regulations are being used to give American firms an unfair trading advantage by placing intolerable restrictions on our high-technology firms.

Our export industry is being savagely disadvantaged as a direct result of the policy of a country widely accepted as our foremost ally! The American attitude generally seems to be "Screw the rest of the world."

PAUL MILLER
Gleadless, Sheffield, England

Thank you for your analysis. I haven't enough facts to be able to comment, but I'm glad to hear about this.—Jerry

THINKTANK, MACINTOSH VERSION

Dear Jerry,

You may recall me. I am "the only person on earth that (you) know of who was ever disappointed by a Living Videotext product." This came up at the word-processing panel at Westercon. I appreciate your comments regarding Mr. Winer's integrity, but the Macintosh version of ThinkTank has so many problems that they outweigh its benefits.

I think it would behoove you to take a hard look at the Mac incarnation of what is a wonderful program on the Apple II and the IBM PC. You will find multiple violations of the Mac interface, making the product jarring to use for Mac users. The screen shows a monofont, but all printing is done in a proportional font—what you see ain't what you get. Scroll bars are nonstandard. Indentation is specified in spaces rather than inches or points.

(continued)

(What's a space in a proportional font?) There are bugs in the editor; spaces are spuriously generated or dropped, and the user doesn't always find out about it until the document is printed. The general appearance is that the Mac version is a hasty port from the IBM PC or Apple II version. What's more, LV wants $35 for what is essentially some bug fixes (this is on top of the $100 that I've already put up for the upgrade from the very limited ThinkTank 128 to ThinkTank 512). It should be noted that Microsoft, Software Publishing, and even Apple Computer have provided bug fixes for their Mac software at no charge to the user.

I wrote to Peter Winer at LV about these issues in June 1985 and have never received a reply. As I've implied, the picture you have of Living Videotext may be incomplete and therefore inordinately positive. On the Mac, at least, ThinkTank is a great idea poorly executed.

Also, I would like to include more information about the L5 Society (the text of the Commercial Space Incentives Act, for example) in the Library section of my BBS (The Citadel, (818) 339-4704, 300/1200 baud, 8 data, 1 stop, no parity, 24 hours, 7 days). Is there a source of machine-readable or downloadable L5 information? To whom should I write for more information? I would like to use the BBS to further the goals of the Society, if it is at all possible.

By the way, does the terminal attached to Zeke display larger-than-life characters? I have often read and heard your complaints about the Mac's screen size. What puzzles me about this is that the characters on the screen are actual size. The only conclusion I can come to is that your usual monitor must be larger than life, which, I do grant, would be easier on the eyes.

FRED CONDO JR.
Covina, CA

I am not familiar with the Macintosh version of ThinkTank and have never used it, so I have no way to comment on that part of your letter. I'm certain I never recommended it for the Mac.

The L5 Society (1060 East Elm St., Tucson, AZ 85719) can probably furnish you with a machine-readable material. Write them; they are in need of reliable hackers.

My usual monitor is a 15-inch Hitachi and is indeed "larger than life." Thank heaven.—Jerry

PROINDEX

Dear Jerry,

Thanks for the mention of Proindex in your BYTE column. Proindex has not been available as a "shareware" product for the last two years. The program is now sold through advertisements in the backs of various IBM PC–specific magazines.

Proindex retails for $89.95 and includes the indexing program, a program for merging separate indexes (Merge), and typeset documentation. The program may be ordered from

Elfring Consulting, Inc.
4N899 West Mary Drive
St. Charles, IL 60174
(312) 377-3520

Thanks again for the mention in your column.

GARY ELFRING
St. Charles, IL

My apologies; the original copy I had was shareware and I must have neglected to update my files.

I find Proindex quite usable, and I hope you sell a bundle of them.—Jerry

 Inquiry 34



The Best of BIX is a brief look at the activity on BIX, the BYTE Information Exchange. The messages shown here are only a fraction of the thousands of messages each month from the many conferences on BIX. For information on joining BIX, see page 372.

AMIGA

The Amiga window is software-oriented this month with a discussion on VSprites, Bobs, and beam avoidance.

VSPRITES

```
amiga/softw.devlpmt #2292, from sduff (Stephen Duff)

I have seen the example hsprite.c in the listings
section and had no trouble getting simple hardware
sprites to work in my program. VSprites, on the other
hand, are giving me some problems.  I have tried
following ROM Kernel Manual and still no VSprites.
What is the proper procedure to display a VSprite?
sduff
```

```
amiga/softw.devlpmt #2293, from cheath (Charlie Heath)
a comment to message 2292

All I've done is Bobs (blitter objects) and simple
sprites.  Haven't actually heard of anybody getting
VSprites working, though it sounds like a few have
tried without success!
```

```
amiga/softw.devlpmt #2294, from jmackraz (Jim Mackraz)
a comment to message 2293

The recommendation I've got here is "Don't use
VSprites."
If I learn more, I will tell you.
```

```
amiga/softw.devlpmt #2298, from jsan (Jez San)
a comment to message 2294

Jim -
   Don't VSprites work? If not, why not? Will it be
fixed for v1.2?  Or v1.3?

   I was intending to knock up a quick 'Defender' game,
using VSprites. But if they don't work, that doesn't
look possible, does it!?
```

```
amiga/softw.devlpmt #2308, from lnoland (Leslie Noland)
a comment to message 2294

Uhh.. Jim,
   While I understand that it is pointless to try to
use something that doesn't work, I certainly hope that
the response "Don't use VSprites" had an implicit
"until we get the problem fixed" following it.  I would
hate to think that something that was repeatedly touted
in reviews, advertising it. (I seem to recall),
documentation, etc. doesn't work and that A-C's
official response is going to be that we simply
shouldn't try to use it.

   I realize that, though you are an A-C employee, you
are not necessarily their spokesman and also that what
you say here is informal in nature (unless explicitly
rendered as a statement of policy), but I wish you
would make this a bit more clear.
```

```
amiga/softw.devlpmt #2317, from jmackraz
a comment to message 2308

A little research appears to be paying off.
VSprites are not recommended because they are not
positioned relative to a ViewPort (screen) but rather
the View (entire display).  Thus, Simple Sprites are
recommended, if you do not need the virtual
(dynamically reassigned) characteristics.
   I have located an example of VSprites in use, by
Dave Lucas, and when he cleans it up and gets it to me,
and if I can figure out how to upload to this net, I
will do so.
   Any suggestions on that, Charlie?
```

```
amiga/softw.devlpmt #2323, from rjmical (RJ Mical)
a comment to message 2308

Jim is right about using Bobs (in reference to the idea
of using Bobs to move text around in the gadget
editor).  My original claim was that using Bobs would
greatly simplify the programmer's effort.  But using
```

(continued)



Bobs also has the advantage of automatically eliminating visual unpleasantries as Bobs do beam-avoidance to create clean changing imagery. Someone wondered why 1.2 icons flickered when multiple Bobs were moved simultaneously. Don't know why that would be, but I suspect it's not a Bob problem and also not a Workbench problem. Probably something else was happening. For an example of many Bobs moving at once, see the Molly demo program from Amiga (don't know if this is still generally available).

I'm running 1.2 right now, and I drag multiple icons without any perceptible flicker. In fact, it looks pretty good!
RJ >:-{)*

---

amiga/softw.devlpmt #2325, from jim_kent (Jim Kent)
a comment to message 2323

Hey RJ, you wouldn't happen to have any old VSprite stuff lying around? From what I hear the y sorting stuff and re-using all works OK, and that's the hard part. Is the problem just getting them to work with Intuition's slidable screens?

Also I've been wondering how Intuition has a solid background behind the last screen. When I was doing my own viewport/view manipulations, I always got garbage on the part of the screen not covered by a viewport.

---

amiga/softw.devlpmt #2326, from cheath
a comment to message 2323

Bobs do beam avoidance? That's news to me - the only way I've been able to keep Bobs from flickering is with double-buffered screen. One of the not-nice things about the bitmap architecture with blitter is that each bitplane is drawn before the next is started - so you often have a situation in which the display is updated while a large part of the screen is in transition. That sort of stuff doesn't happen without blitter so much, because the software can be written to do all the bitplanes in sync - so there is only a small part of the display that can look narsty at any given time.

ATARI ST

The Atari ST section begins with hard disk problems and a case of the seemingly simple disk crash and goes on to a thread on using Malloc( ) in C.

HARD DISK PROBLEMS

---

atari.st/tech #592, from chrlskuku (Christoph Kukulies)

Today it happened...
My hard disk (Atari grey box) suddenly showed 0 bytes in 0 items. It was heavy-loaded with lot of stuff, about 40 directories with about 1500 files or so, all in all, 15 Mb of the 20 available. Does anyone know how this could have happened (other than typing rm *)? Before I start to reformat it - does anybody have a utility to look at the hard disk blocks to eventually repair it? Help welcome.

---

atari.st/tech #593, from jim_kent
a comment to message 592

If it's 0 bytes in 0 items it's just as likely that the driver has gotten lost. Have you tried re-installing the driver and changing resolution from Preferences? I hope that's it. I don't know of any utilities that look at the disk sectors directly.

---

atari.st/tech #600, from alexl. (Alex Leavens)
a comment to message 592

Bomp! Bomp! Bomp!
Another one bites the dust! :-)
Sorry, just couldn't help it. Same thing happened to me Saturday. It's reformat time (your FATs have gotten roached). Next time you format it, partition it into four 5-Mb logical drives--this locates the FATs in different places, and makes roaching of the entire disk much less likely. Then you can use say drive F to back up drive C.
Good luck.

---

atari.st/tech #605, from chrlskuku
a comment to message 600

Yes, I reformatted it already. Using Dust from Hippo, which allows you to look at disk blocks (sectors), showed me that some important sector was zeroed. By the way, this Disk Utility didn't work quite correctly because it said: "Not enough memory for FAT." So I gave up and reformatted it.

But, tell me, how can I partition the disk into different drives? Do I have to have a special program for this?

---

atari.st/tech #610, from neilharris (Neil Harris, Atari Corp.)
a comment to message 605

If your hard disk driver floppy did _not_ have the new format program which uses GEM and also partitions your drive, then your problem is that you're using old software for the driver -- contact Atari and get the latest disk right away!!!

---

atari.st/tech #629, from jtittsler (Jim Tittsler, Atari Corp.)
a comment to message 605

You can partition it yourself if you like Chris using the information in the Hitchhiker's Guide and your favorite sector editor (or FORTH). The zeroth sector contains the partition map with pointers to (up to) 4 partitions. Each of the partitions has a "boot sector" which contains the normal disk prototype BPB.

MALLOC

---

atari.st/c.language #179, from chrlskuku

I downloaded Tim's mallocer because I had problems with Malloc (gemlib). Now, although the mallocer works, my program still doesn't. I've #defined malloc __malloc and have written a function:

```
char *
__malloc(arg)
int arg;
{
 return( (char*)(Malloc((long)arg)));
}
```

to stay compatible with source code in respect to standard calls. I have a 1-meg machine, TOS (US) in ROM. My program is linked with gemstart.o gemlib aesbind vdibind libf, etc. After appl_init(), open_vwk(), I do some malloc()'s to allocate some nodes (only 200 bytes or so, application stuff). Asking available=malloc(-1L) tells me I have enough (xxxxx) memory. To verify this, I did just for testing a:

```
while(malloc(sizeof (struct node))nnodes++;
```

Totally in contradiction to what is expected by calculating from the value of available I now only get poor 132 or so nodes allocated (sizeof node is 18, but is not relevant).

Please don't tell me "use the L*T***E compiler. When such things can't be done with the dev-pack then

(continued)

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Atari should please explain why they called it "developer's package?"

Do you have any idea? Comments would be welcome.

---

atari.st/c.language #180, from sgrimm (Steve Grimm)
a comment to message 179

I always had trouble mallocing in a routine that uses local variables. Try removing the parameter (set a global variable and have your malloc look at that variable).

---

atari.st/c.language #181, from chriskuku
a comment to message 180

Thanks. Your tip sounded promising, but looking at my program, I saw that I've already done so. I call malloc(size) with size globally declared.

---

atari.st/c.language #184, from jim_kent
a comment to message 181

Chris - I've uploaded some memory management stuff into atari.st/listings. You probably would be best off getting Malloc to work somehow, but this might be a useful kludge to keep you going in the meantime.

---

atari.st/c.language #185, from chriskuku

Jim, thanks for your example listing. I'll try it as a last escape. Meanwhile, I've cut down the problem to a short example':

```
/* tstmallo.c  CPK 4-JUL-86
 * this simple example shows my usage of Malloc
 * and it's  mal(loc)function (if I haven't overlooked
something).
 */
#include "osbind.h"
/* define some node stuff */

struct node {
   int x,y,z,pen;
   struct node *next;
  };

struct node *first,*last;

main()
{
 int nnodes = 0;
 struct node *lastbutone;
 first = (struct node *) Malloc( (long)sizeof (struct
node));
 while( (last = (struct node *) Malloc((long)sizeof
(struct node))) ) {
        lastbutone = last;
        nnodes++;
       }

 printf("\n%d Nodes of size %d\nStart address
%08X\nLast  address %08X",
                      nnodes,sizeof(struct
node),first,lastbutone);
}
```

Maybe you can try it on your machine. I always get only about 100 nodes allocated and then finito.
Any help welcome.

---

atari.st/c.language #186, from jim_kent
a comment to message 185

Chris - I just tried your code. I'm working with Megamax, a 520ST with a 1-meg upgrade and TOS in ROM, and a hard disk.

With me, it got 268 nodes before it quit. Curious thing is that when I added a character array to the node structure to make it bigger it still got 268 nodes. It allocated 268 512-byte nodes OK! I've heard from various sources there are problems with Malloc. I'm not sure if I get more nodes than you 'cause I've got a meg, newer ROMs, or better luck. Still, it's very easy to allocate more than 268 times. Have you tried malloc with a little m? Yep, I'm sure glad I've got some proprietary (er, now public domain, I guess) memory management routines. I've had a lot of problems with various mallocs and Mallocs on this machine. Actually, the routine I uploaded has been simplified to allocate out of an array. What I really do in my "real" code is Malloc(10K), and then add the pointer to my free list with a mfree(pt, 10K) when the free list gets empty. Did I say 10K, I meant 32K, so it'll have some blocks big enough to hold a whole screen!

I've heard that the Megamax Malloc works in a

(continued)

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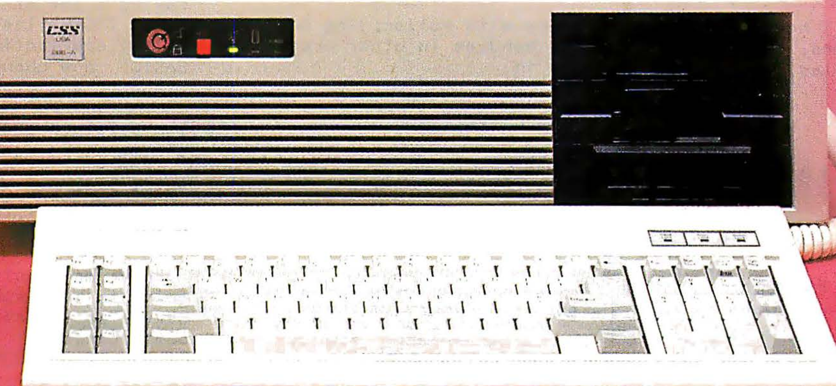
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similar way. I never got the Alcyon one to work properly. I forget if I got Lattice Malloc to work. I've never actually tried Megamax. It's kind of nice being able to peek at your own free list anyway for debugging, so since I got the sources, I use' em.

---

atari.st/c.language #187, from sgrimm
a comment to message 185

According to the GEMDOS manual, one program isn't supposed to malloc more than about 20 times, or pointers start to get messed up. Try mallocing one big block and accessing it as an array:

```
#define NUMSTRUCTS 100      /* The number of structures
you want in your array */

struct node *nodearray;

alloc()
{
  nodearray = (struct node *)
Malloc((long)sizeof(node)*NUMSTRUCTS);
}
```

Hope that helps.

---

atari.st/c.language #198, from timpanton (Timothy Panton)
a comment to message 179

I don't know the answer to this one, I haven't played with Malloc for months (I wrote mallocer to test my 1-meg upgrade). However, looking at some code, I see I didn't trust casts in macros, i.e.,

```
    Malloc((LONG) thing);
where thing is a word, I seem to have used
    Malloc(lthing);
```

where lthing is a long, I'm not sure why; distrust of the preprocessor I guess.

My understanding of how Malloc() and malloc() differ is this:

TOS maintains a pool of memory. When a program starts up, it is allocated an amount of memory for code, data and stack. With GEMstart and GEMs this includes some extra to allow malloc to allocate from this area, and they include sbrk() which helps manage this allocation.

Appstart and accstart do not have this extra memory, nor do they include sbrk(), so malloc() can't be used. Malloc() is a TOS function which returns a pointer to free memory *outside* the programs area.

Thus, Mfree() really frees up memory for use by another program (say a print spooler accessory) whereas free() does not. free() in UNIX behaves the same way.

I haven't had any problems with malloc()ing too many times, but from the way TOS behaves in other areas (files, etc.) I can believe it.

IBM PC AND COMPATIBLES

The IBM section begins with questions on using ANSI.SYS for portability in a BASIC program. The end of this thread goes into a message from the BASIC conference for tips on calling assembly language routines and ROM BIOS functions from BASIC.

USING ANSI.SYS

ibm.pc/other #229, from jburtner (Jeffrey Burtner)

Where can I find additional information on the use of ANSI.SYS? I am trying powerful {looking} features of ANSI.SYS to manipulate the screen in BASICA. Also, I could use a recommended reference for the interrupt codes and DOS calls available.

---

ibm.pc/other #235, from feenberg (Daniel Feenberg)
a comment to message 229

Doesn't BASIC bypass MS-DOS for screen I/O and is not ANSI.SYS ignored by any BASIC program?

---

ibm.pc/other #236, from richard (Richard Shuford)
a comment to message 229

ANSI.SYS is documented in the DOS Technical Manual, which, since version 2.1, has been a separate volume (and purchase) from the DOS User's Manual.

I don't normally recommend the following periodical, but the November 1985 issue of "PC World" contains an article beginning on page 244 (excerpted from "The Fully Powered PC" by B. L. Alperson, A. Fluegelman, and L. J. Magid) that discusses the use of ANSI.SYS.

However, it may not do you any good, because I suspect that BASICA may bypass the normal console drivers for much of its work; therefore, you may not be able to do much with ANSI.SYS in conjunction with BASICA.
.....RSS

---

ibm.pc/other #237, from dmick (Dan Mick)
a comment to message 235

Not if you use OPEN to open a device and then write to it with PRINT#. I think the actual device changes from interpreter to compiler. In the interpreter I believe it's SCRN: and in the compiler TRM: or CON: or mebbe CONS: I'm away from the machine that has the answer on its hard disk, but I know you can drive ANSI from both int. and comp. with the OPEN / PRINT# trick..

---

ibm.pc/other #241, from btonkin (Bruce Tonkin)
a comment to message 229

Why are you using ANSI.SYS stuff from BASIC in the first place? Given that you already have LOCATE, CSRLIN, POS, COLOR, and SCREEN commands (not to mention graphics), it seems a little strange to me. Kinda like going back a few years to the days of dumb terminals.

---

ibm.pc/other #242, from jburtner
a comment to message 237

That's exactly what I'm trying to do. I open "ANSI.SYS" as #1, then try to send my console output through it using IOCTL #1, etc. But I'm still not having a lot of luck; I keep getting a function error on my IOCTL line. It's very easy from Turbo Pascal, but my application must be written in BASICA or GW-BASIC. How about a way to clear to end of line or clear to end of screen for use in BASICA?

---

ibm.pc/other #245, from richard
a comment to message 229

Perhaps if you are serious about complex applications, you should get the replacement, NANSI.SYS, from Hersey Microsystems.

Any implementation of the ANSI X3.64 standard is going to be a subset. I don't think that any real device could possibly use all the codes and be comprehensible. The full list of codes is there to provide a standard way of doing a certain group of functions. If your device doesn't do a given function,

(continued)

then it doesn't need to recognize the code for the function.

I observe that "ms.dos/long.messages" msg. 10 is the text of ANSIX364.TXT, a file I posted awhile back on BYTEnet/Listings. Thank you for posting it locally, sir.

---

ibm.pc/other #247, from dmick
a comment to message 242

I know I didn't use IOCTL. The reason I did it was to make quick modifications to a CP/M public domain touch-type program that defined command strings to control the terminal and therefore ran on a lot of different systems. I kept the basic structure for portability and just changed the command strings to do ANSI functions, then changed all the PRINTs to PRINT #1s after I'd opened the device. In Zenith's BASICA (GW-BASIC) and I'll bet in IBM's too, one may use:

```
OPEN "CON" FOR OUTPUT AS #1
PRINT #1, CHR$(27) + "[2J";
```

to clear the screen. It works, bypassing BASIC's I/O. Of course, ANSI.SYS must be installed first. In the QuickBASIC compiler, the filename is different, I believe...but it works there, too. If I can get at the machine that has it next week, I'll post what name to use with QB. But I agree with Bruce...if you don't have to, use BASIC's functions...don't have to worry about having ANSI.SYS resident, and you can do more. You'll have to write a CLREOL and CLREOS function, but they're awfully easy to do.

---

ibm.pc/other #248, from jburtner
a comment to message 247

OK. I'll try your PRINT #1 method. But as for writing a CLREOL or CLREOS function, I'm missing the awfully easy part somewhere. Could you explain how to do it short of sending lines of spaces or nulls to the screen? (That is so slooooowwwww.)

Do you happen to know how to address the screen memory directly from the IBM BASIC (either GW-BASIC or BASICA)? Several of us have taken a whack at trying to read or write to it directly without much success. Our best guess is that BASIC is relocating it's memory (64K) in an area away from the screen so that we cannot reach it using POKE.

---

ibm.pc/other #249, from dmick
a comment to message 248

Well, what I was thinking of as far as CLREOL, etc., was printing spaces. You're right, that can be slow. An assembly subroutine would be quicker, and that's not so easy to do with the interpreter although it's a snap from the compiler.

As far as accessing display memory...any memory can be accessed with a combination of the DEF SEG and PEEK/POKE statements. PEEK, POKE, and several other statements that take addresses as arguments take 16-bit addresses which are considered offsets in the default segment. If unset by DEF SEG, this default segment is BASICA's data segment, where program source, variables, etc. are stored. VARPTR, for example, returns the offset of a variable in the variable table as a 16-bit offset into the default data segment. Thankfully, this is *not* the segment used for display RAM. Some interesting things could happen on-screen if it were! The segment address for mono video on IBMs is B000H; for color display adapters B800H. So to access video RAM, first do DEF SEG = &HB000 for mono machines or DEF SEG = &HB800 for color machines, then PEEK/POKE refer to video RAM. Be sure to reset this before you do anything like CALL or BLOAD or something else that requires an address, though.

Are you using the interpreter exclusively? Screen updating using spaces is a lot faster with the compiler, and the newest for the IBM, QuickBASIC 2.0, should make a Turbo'er feel right at home.

---

ibm.pc/other #251, from jimkeo (Jim Keohane)
a comment to message 248

>CLREOL & CLREOS from BASIC

Jeff, see basic/programming #40 for assembler calls for QB posted by BTonkin. Also, see /programming #48 for some non-assembler means of making DOS and ROM calls. Specifically, there's a ROM call to scroll up or down a specified window on the screen. If you specify zero as number of lines to scroll, the whole window can be blanked. This can mimic a CLREOS or CLREOL if cursor is at col 1. If cursor at different column, you can still do a CLREOL by specifying a one-line window. CLREOS would be a full scroll zero of any lower lines.

---

ibm.pc/other #253, from bomb (Jerry McReynolds)
a comment to message 229

Jeff, to make a quick answer to your query about ANSI.SYS, yes, you can access the ANSI driver from BASIC.

You should have the system boot with the statement;

```
DEVICE=[D][PATH]ANSI.SYS
```

in your config.sys file. To access the driver from BASIC (or any language) all you have to do is write to the device "CON," which happens to be stdout. The driver that you install in your config.sys file will take precedence over the "Glass TTY" console driver that DOS installs.

The statement, OPEN "CON" FOR OUTPUT AS #1, will open the stdout file for writing. The statement, PRINT #1, "Hello", will print the word Hello at the current cursor position and also issue a Carriage Return Line Feed.

The complete subset that the ANSI.SYS driver supports is available to you through the PRINT #1 statement. The supported escape sequences are listed in the DOS Technical Reference Manual.

For example, suppose you wish to clear the screen, then position the cursor at line 12, column 20 and print the string "Enter Your Name Please:", the following example will do just that:

```
10 OPEN "con" FOR OUTPUT AS #1
20 PRINT #1, CHR$(27);"[2J";
30 PRINT #1, CHR$(27);"[12;20H";
40 PRINT #1, "Enter Your Name Please:";
50 CLOSE #1
```

Line 10 will open the console device for writing.
Line 20 will clear the screen.
Line 30 will position the cursor at row 12, column 20.
Line 40 will print the string.
Line 50 will close the file.

Good luck, hope this tidbit helped.
P.S. - The escape sequence for CLREOL is named EL and is "ESC [k". Also note that the characters -are- case-sensitive.

---

ibm.pc/other #254, from jburtner
a comment to message 253

Yes, so I found out. So for any others who may have been watching (with interest or revulsion), here is the final set of commands that I've decided upon for inclusion in my program:

```
10 Open "CON" for Output As #1
20 ETB$=CHR$(27)+"[s"
25 FOR X=1 TO 24:ETB$=ETB$+CHR$(27)+"[k"+CHR$(27)+"[B":NEXT X
30 ETB$=ETB$+CHR$(27)+"[u"
```

(continued)

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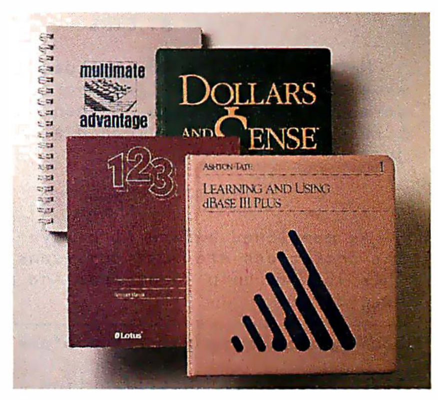
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```
40 ENQ$=CHR$(27)+"[s"+CHR$(27)+"[K"+CHR$(27)+"[u"
```

I may now clear the screen to the bottom at any time by locating at the position to clear from and:

```
PRINT #1,ETB$
```

Notice that line 20 includes the cursor position save function as the first part of my clear to end of screen function. Line 30 then returns to the original cursor position. To clear a single line to the end, I just:

```
PRINT #1,ENQ$
```

As mentioned before (I always learn the hard way!) the characters are VERY case-sensitive. I hope that this is some help to others. And many thanks to all who helped!

basic/programming #40, from btonkin

TITLE: QB screen scroll routine in assembler

```
 title DSCROLL.ASM: A LINKABLE ROUTINE TO SCROLL THE
SCREEN DOWN.

        ;THIS ROUTINE IS PASSED THE UPPER LEFT CORNER TO
        ;SCROLL. THE LOWER RIGHT CORNER IS PERMANENTLY
        ;SET TO ROW 22, COLUMN 79.  THE ROUTINE WILL USE
        ;A BIOS CALL TO SCROLL ALL LINES IN THAT PAGE
        ;DOWN AND INSERT A BLANK LINE WITH NO ATTRIBUTES
        ;AT THE TOP OF THE SCREEN.  THE TOP OF THE
        ;SCREEN WILL BE. THE TOP LINE INVOLVED IN THE
        ;SCROLL. TO SCROLL THE WHOLE SCREEN, SET THE TOP
        ;LINE TO ZERO.

        ;(0).  WRITTEN BY BRUCE W. TONKIN ON 9-18-85
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DATA     SEGMENT WORD PUBLIC 'DATA'
STORAGE  DW   16
DATA     ENDS
DGROUP   GROUP     DATA
CODE     SEGMENT BYTE PUBLIC 'CODE'
         ASSUME CS:CODE, DS:DGROUP
         PUBLIC DSCROLL
DSCROLL  PROC FAR
         PUSH BP                ;SAVE BASE POINTER
         MOV  BP,SP             ;SET UP TO ADDRESS OFF OF
                                ;BP
         MOV  BX,[BP]+6         ;GET THE ADDRESS OF THE
                                ;PARAMETER
         MOV  CX,0              ;ZERO CX REGISTER
         ADD  CX,[BX]           ;PUT ROW ADDRESS INTO CX
         MOV  CH,CL             ;MOVE ROW TO CH
         MOV  CL,0              ;SET COLUMN NUMBER TO ZERO
                                ;FOR UPPER LEFT
         MOV  DH,22             ;BOTTOM ROW NUMBER
         MOV  DL,79             ;BOTTOM COLUMN NUMBER
         MOV  BX,112            ;SET ATTRIBUTE TO USE INTO
                                ;BH
         MOV  AL,1              ;NUMBER OF LINES TO
                                ;SCROLL, 0 MEANS ALL LINES
         MOV  AH,7              ;BIOS FUNCTION CALL
         INT  010H              ;INTERRUPT 10 HEX=16
                                ;DECIMAL
         POP  BP                ;RESTORE BASE POINTER
         RET  2                 ;RETURN AND REMOVE ONE
                                ;PARAMETER FROM STACK
DSCROLL  ENDP
CODE     ENDS
         END
```

DOS & ROM BIOS CALLS FROM BASIC

basic/programming #48, from jimkeo

I read with interest the various ROM calls coded in assembler posted by btonkin. Other languages I use have a general purpose call where the INT # is passed as well as the value of certain registers. I thought it would be nice to have such a routine in BASIC. Following is a first pass at it. It does not currently return the new reg values after the interrupt nor does it return the FLAG settings (used by some DOS calls). However, it should suffice for many uses.

Of the 3 "DEF FNxx" statements, the one for FNCC$ is used to assign to a string an assembler routine that is built on the fly using the INT value passed as well as various register values. The other 2 FNxx's merely break up FNCC$ into 2 pieces for easier handling.

The program below issues a Video INT 16 (&H10) with AH set to 6 for scroll up. When AL=0 (as it is in this example) the entire window is blanked. CX gives the upper left corner as 0,0 and DX gives the lower right corner as 10,40. BH specifies the attribute used to fill in new lines.

Since this is the first time I've played with assembler called from BASIC, I'll leave it to the more experienced to craft a version like:
100 CALL IR(IN,AX,BX,CX,DX,etc....)

Such a version could also return the register values after the interrupt as well as the flag settings.
– Jim Keohane

```
10 DEF FNAA$(DS,BX,CX,DX,BP,SI,DI) =
   MKI$(&H5655)+MKI$(&H61E)+CHR$(&HBB)+MKI$(BX)+CHR$
   (&HB9)+MKI$(CX)+CHR$(&HBA)+MKI $(DX)
   +CHR$(&HBD)+MKI$(BP)+CHR$(&HBE)+MKI$(SI)+CHR$(&HBF)
   +MKI $(DI) +CHR$(&HB8)+MKI$(DS)

20 DEF FNBB$(AX,ES,IN) =
   MKI$(&HD88E)+CHR$(&HB8)+MKI$(ES)
   +MKI$(&HC08E)+CHR$(&HB8)+MKI$(AX)+CHR$(&HCD)+LEFT$
   (MKI$ (IN),1) +MKI$(&H1F07)+MKI$(&H5D5E)+CHR$(&HCB)

30 DEF FNCC$(IN,AX,BX,CX,DX,BP,SI,DI,DS,ES) =
   FNAA$(DS,BX,CX, DX,BP,SI,DI)+FNBB$(AX,ES,IN)

40 GOTO 60

50 I=VARPTR(S$):J=CVI(CHR$(PEEK(I+1))+CHR$(PEEK(I+2))):
   CALL J:RETURN

REM AH=6,AL=0 to clear all,BH=attr, Dh=line 10,
   DL=column
REM 40:clear window
REM Video INT 16 (Hex 10)

60 S$=FNCC$(16,&H600,&H4E00,0,&HA28,0,0,0,0,0):GOSUB 50

70 END
```

P.S. To issue Shift-PrtSc from BASIC code:
60 S$=FNCC$(5,0,0,0,0,0,0,0,0,0):GOSUB 50

P.P.S. I know Shift-PrtSc is in the BASIC manual already, I just wanted to give another example!

MACINTOSH/APPLE II

With this issue, the Macintosh window expands to become the Macintosh/Apple II window. The section begins with a long message on HFS and the Macintosh hard disk. The next thread covers the Apple II, with a question on loading and using files above the magic HIMEM limit.

HFS, YOUR HARD DISK, AND YOU

macintosh/long.messages #29, from cgibson (Christopher Gibson)

(continued)

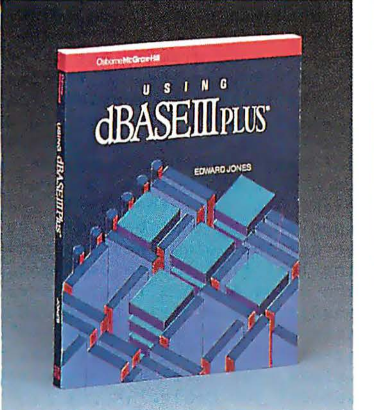
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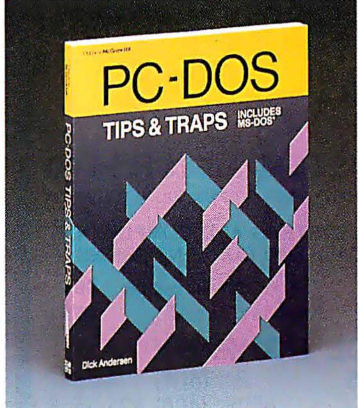


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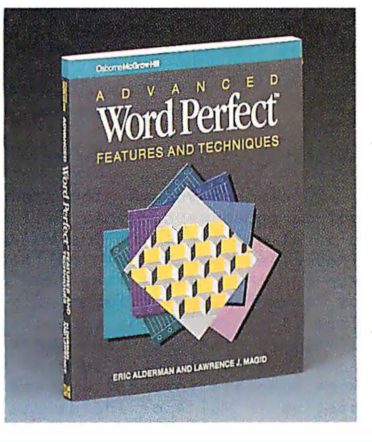
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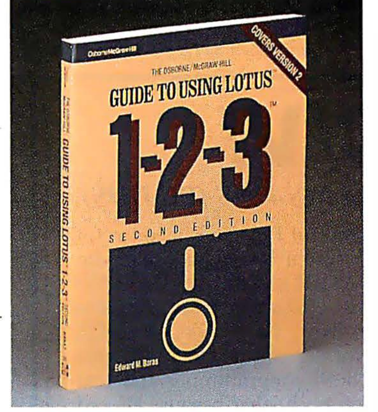


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If you have an HFS hard disk hooked up to your Mac or Mac Plus, then you must have noticed that whenever you reset your Mac without choosing Shut Down (such as hitting the reset button, a system bomb, or even an application doing a reset when it quits), the hard disk will perform some mysterious internal rebuilding, with furious disk accesses that can last up to two minutes before the familiar "Welcome To Macintosh" message appears. With a lot of puzzling, and more than a little help, the reason - and the solution - are at hand. But first, a short explanation is in order.

NON-TECHIE SECTION
==================

Whenever a disk - any disk - is inserted into a drive, it is "mounted" by the ROM routine MountVol. While a hard disk is not inserted in the traditional sense, it goes through the same MountVol routine. One of the things the MountVol routine does is check for a special block of information called the Volume Control Block (VCB for short). Inside this is lots of information about the volume, depending on whether it's an HFS or MFS volume, a regular disk or a non-ejectable disk, etc. But the key to this shortcut lies in a special flag that basically tells the computer whether or not the volume was *properly* ejected and unmounted the last time the volume went "off-line." Depending on the value of this flag, the volume will either be mounted immediately (since the Mac assumes it's OK), or else (if on an HFS volume) it will begin to rebuild two special files the Finder uses to keep track of the volume. If this has completely left you behind, then I suggest you Control-K out right now, because it just gets worse, and besides, unless you have a pretty good grasp of what's going on behind the scenes, you should probably not be executing a routine that has you playing around in memory with a debugger.

SECTION OF TECHIE STUFF
=======================

BUT FIRST, A BIT OF HFS BACKGROUND

On any HFS volume, there are 3 structures to handle volume space management, file mapping, and file allocation. These are the Volume Bit Map, the Extents Tree File, and the Catalog Tree File. The Volume Bit Map and the Extents Tree File handle the equivalent job as the MFS volume allocation block map. The Catalog Tree File handles the equivalent job as the MFS file directory. The two trees are set up as B-trees, and each node consists of several types of records. For more complete information, see the new File Manager section in Vol 4 of Inside Macintosh.

Whenever the Mac recognizes that a disk has been inserted, the operating system calls the MountVol routine in the File Manager (the rest of this section assumes HFS volumes, unless specifically mentioned otherwise). One of the first things the MountVol routine does is to read in the volume information at the beginning of a volume, and build a copy of it in memory in a data structure called the Volume Control Block (VCB). Each VCB is a 178-byte non-relocatable block that contains volume-specific information. This block is documented (accurately) in volume 4 of Inside Macintosh. One of the fields in this record is an INTEGER field 'vcbAtrb'. Herein lies the key.

Before I get too specific, let me give a little general disclaimer: this stuff was gathered by a combination of insight, debuggers, and time. After many sessions of trapping, bombing, resetting, and interminable delays while our various HD's "rebuilt" themselves, we narrowed down the possibilities. After a few glances at the revamped File Manager section of Inside Macintosh Vol.4, we felt reasonably confident in our conclusions. But, these are not the words of you-know-who, and I not only ask, but encourage anyone who has the inclination to do so to please check my conclusions. I would always rather be proven wrong a

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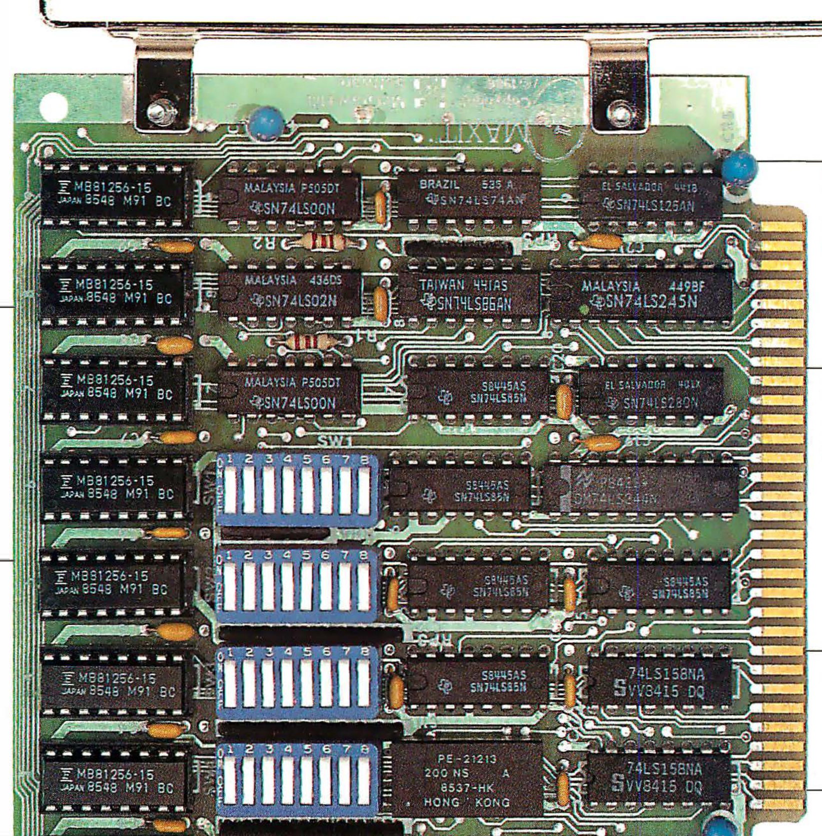
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million times than screw up my hard disk even once. But, if this sounds overly willy-nilly, let me say this: I have personally used the shortcut below to avoid the hard disk tree restructuring many, many times. It has been used in many different situations, and we have yet to lose a byte of data. When applied with a reasonable dose of discretion, I don't think there is any reason to worry. So, if we are all in the proper mood of "controlled skepticism," let us continue:

Of the 16 bits in this field, Apple documents only 8 as follows:

Bit	Meaning
0-4	Set if inconsistencies were found between the volume information and the file directory when the volume was mounted.
6	Set if volume is busy (one or more files are open)
7	Set if volume is locked by hardware
15	Set if volume is locked by software

From our best efforts, however, the only bit WE find being changed is bit 8. We have tried again and again, and still bit 8 seems to come up every time. Basically, what we find is that this bit, ON DISK, is set to 1 if the volume was properly flushed and unmounted the last time the volume went off-line. This is done by the Eject routine, which goes into the VCB, sets that bit to 1, and then writes the block to disk. This is done just before the volume is unmounted, and I don't think that it is done by other routines, such as FlushVol, that don't explicitly call Eject (although Eject does call FlushVol).

To gain an insight into how the system worked from session to session, we examined that bit. As soon as the volume is mounted, and the VCB is read into memory, the bit is set to 0, and written back to disk. This way, if the volume should go off-line in any way that is not performed by the Eject routine, the block will not be updated, either in memory, OR ON DISK. I'll get to what happens when a disk is mounted with this bit set to 0. The important point here, especially for programmers, is that if the system bombs, or gets hit by a power failure, or is reset, either by the programmer's switch OR THE REBOOT COMMAND, the bit is left at 0, even if FlushVol was constantly called for safety (this is still a good idea, however, to help assure the integrity of your data files).

Anyhooos, when the MountVol routine is called, it checks that bit, and if it is zero, the MountVol routine gets the disk to start rebuilding these files, on the assumption that if the bit was not set, then the volume may have been left in some inconsistent state, so it's time to make sure, and build these trees from (probably) scratch. Due to the recursive natures of building the B-tree structures, this is most likely what is occurring when you try to boot or mount a volume right after you bomb or reset. On a 20- or 30-megabyte hard disk, this can take as long as two minutes. For developers, who usually follow the Edit-Compile-Run-Crash-Reboot cycle of writing programs, this time can quickly add up. (One quick note: this same action occurs on ANY HFS volume, even a floppy. But on a floppy, the time to rebuild these is much shorter, so you probably just haven't noticed it.) Now that you know what is happening, maybe we should examine how to avoid it, even under a bombing situation. ("Finally," I can hear you thinking, as a collective sigh of relief rises from the readers.)

THE SHORTCUTS AND FIXES
=======================

The first method I will (briefly) examine is aimed at those developers who insist on having their programs

(continued)

reboot the Mac when you quit. (I hate that, but if you're gonna do it, now you don't have an excuse not to do it right!)

THE FIX

For the high-level programmer, the fix is relatively simple. The Reboot command DOES NOT perform this vital portion of the Eject routine. So, whenever your program is planning on rebooting the Mac, make sure you Eject ALL mounted volumes before you reboot. By doing this, you will avoid pi**ing off the poor people who are using your game.

THE SHORTCUT

So, what do you do if the Mac bombs, and you don't want to wait around while the hard disk does its thing? Try this simple routine (the essence of what it does is to call the Eject routine before you reboot, in order to flush the volume buffer and set the critical vcbAtrb bit):

First of all, you must have Macsbug installed on the Mac. Then, anytime you need to reboot, simply type the following commands (the ">" is the Macsbug prompt - don't type it).

```
> SM 10010 A017 0000 0000 FFFF
> PC 10010
> A0 10000      (that's "A-zero")
> T
> RB
```

Explanation of Debugger Commands

```
> SM  10010  A017  0000  0000  FFFF
```
puts the Eject A-trap, ioNamePtr, and iovRefnum into memory.

*NOTE: this will only be correct if you boot from your hard disk. If you boot from floppy, or do not use a hard disk, this will not be valid. On the other hand, if you are floppy-based, it doesn't take very long to reboot, even if the attribute bit isn't set.

```
> PC      10010
  points the program counter to the A-trap
> A0      10000
  points the A0 register to the Paramblock
> T
  do the Eject routine
> RB
  reboot
```

As with any routine that deals with memory on the machine level, there may be unforeseen circumstances that could cause problems. This routine has been tested on the Mac Plus, with the Apple Hard Disk 20, and the MDIdeas SCSI Hard Disk 20 without any problems cropping up. However, I always suggest using prudence, and you should probably not use this routine if your application died in the middle of some massive file operation. Still and all, it has been very useful and dependable for me.

Please insert the massive legalistic disclaimer that Apple seems to be making the new standard for computer users here.

That's it! Good luck and have fun. Oh yes - feedback is ALWAYS solicited and appreciated!!

---

macintosh/long.messages #30, from hedges (Tom Hedges, Fractal Software)
a comment to message 29

I find that just doing an 'ES' to the Finder followed *immediately* by a shutdown does the trick most of the time, and if the 'ES' fails, then I prefer that the HFS data structure *does* get rebuilt because things probably are really screwed up in memory.

(continued)

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ROUTINES ABOVE HIMEM

apple/language #392, from jrsmith (Anthony Smith)

I'm trying to install a routine above HIMEM. My installer lowers HIMEM by two full pages, installs the routine 1K above HIMEM, and marks the two pages the routine occupies in the system bit map. The routines work fine, but when I try to use the disk, I get a "no buffers available" error. I suspect that ProDOS needs to be told that its temporary buffer should be 512 bytes lower, but I'm not sure how to do that. I suspect it involves using SET_BUF and/or GET_BUF. I tried to use SET_BUF to lower it 512 bytes, but the temporary buffer has no reference number, so the MLI gives me the invalid reference number error. I'm sure the solution is pretty simple. Will someone tell me what it is?

Thank you.

---

apple/language #393, from mdavis (Morgan Davis)
a comment to message 392

No, you don't want to do it that way. If you're messing with BASIC.SYSTEM, you never do anything to the ProDOS system bit map. Only a SYS file (application/interpreter, etc.) should change that -- and since you're ultimately running under BASIC.SYSTEM, only *it* should change the system bit map.

What you want to do is use the BI's "getbufr" call. This allocates space for your machine language programs which will run while BASIC.SYSTEM is in memory. This call lets BASIC know where your routine will be so that when it needs a buffer, it will do so *below* your routine. As it is now, your protected bit map is causing BASIC to get errors when it tries to allocate a buffer where you've protected memory -- therefore, GETBUFR avoids this by letting BASIC *know* where available memory will be.

So how do you do it? It's really simple. First, calculate the number of 256-byte pages that your routine will need, and put that value into the accumulator. Then do a JSR GETBUFR ($BEF5). If the carry bit comes back set, an error has occurred, and you can then just do a JMP ERROUT ($BE09) to let BASIC handle it. This would most likely occur in the off chance that you asked for more pages of RAM than BASIC could give to you, giving a NO BUF's AVAIL error.

If carry comes back clear, then your request has been granted. However, this is one more crucial point. When BASIC returns a clear carry, it also returns a value in the accumulator. This value is the most significant byte of the address where BASIC wants you to place your routine. For example, it might return $92 if the address where your routine should go is $9200.

Of course, this assumes that you have at your disposal some method of relocating your code to the address where BASIC specifies -- because there's no telling where this might be. If your program grows in size, the address will be lower in RAM, since BASIC will ask for you to put your routine as high into free memory as possible. It is also conceivable that someone else's machine language program has been loaded into high memory and is occupying space up there, causing BASIC.SYSTEM to issue your program an even lower address in memory. In short, you really need to have a front-end relocator *after* your call to GETBUFR so that your program will be placed correctly into memory.

If you don't have a code-relocating routine, don't worry. I've written one which takes up just 200 bytes, including all the calls and error handling with BASIC.SYSTEM. Unfortunately, I can't make this code available in source code form, due to restrictions imposed by BIX/Byte/MGH. However, there have been quite a few articles posted in Apple-related magazines detailing the procedure. Even Beneath Apple ProDOS has a relocator (of sorts) for moving a 256-byte (or less) chunk of code.

For more information on allocating space with BASIC.SYSTEM, see the ProDOS programmer's bible: Beneath Apple ProDOS, page A30 "The TYPE Command." One of the ProDOS Technical Notes also details the use of GETBUFR, and its pal, FREEBUFR -- see "apple.dos/tips" for the appropriate Tech Note.

---

apple/language #410, from jrsmith
a comment to message 393

Thanks alot mdavis. Your advice cleared up my problem instantly. The ProDOS Technical Reference Manual gives really lousy advice on that topic. The only place GETBUFR is even mentioned is in a revised memory map in the errata section.

Anyway. Now I have another problem. I've got the routine installed above HIMEM in space allocated by GETBUFR. It is supposed to open a file, then read it, etc. I use GETBUFR to find the file buffer (4 pages), then I store the address it gives me in the appropriate place in the global page and call OPEN through GOSYSTEM. It always returns with NO BUFFERS AVAILABLE or, if I do it twice in a row, with FILE BUSY. If I close the file, the FILE BUSY will usually go away and I'll get NO BUFFERS again. Sometimes the file won't close, however (from immediate mode). So, my main question is why the NO BUFFERS AVAILABLE? Does GETBUFR mark the pages in the system bit map? If it does, should it? Secondary question: Can you close a file using the immediate-mode CLOSE command that was opened with the MLI OPEN command? Is Level involved somehow?

---

apple/language #412, from mdavis
a comment to message 410

You ask some good questions. I'll answer them first, and then explain how one should go about handling disk functions with BASIC.SYSTEM from machine language.

GETBUFR doesn't mark pages in the bit map. I don't think it does, anyway. (It shouldn't!) It just lets BASIC know what memory it has allocated for other things, so that it won't trounce on anybody. Using CLOSE in immediate mode *might* close a file opened through GOSYSTEM, which also uses the parameter tables in BASIC.SYSTEM's global page, but I wouldn't count on it.

Here's how I do DOS functions from machine language with BASIC.SYSTEM. First, before your code calls GETBUFR, have it do this:

```
    lda     $befb           ;save maximum HIMEM setting
    sta     mytop           ;put it someplace safe
    lda     #pages          ;ask BI for so-many 256-byte
                            ;pages
    jsr     getbufr
    bcc     ok              ;c=0 means no error
    jmp     errout          ;yikes, NO BUFFERS AVAIL
                            ;(most likely)
ok  sta     $befb           ;accum has lowest page
                            ;boundary from getbufr call.
                            ;Bring BI's HIMEM down (so
                            ;that frebufr won't wipe us
                            ;out).
```

Then, go ahead and move your code up to where GETBUFR says its okay. Now, when it comes time to do some file manipulation, you'll need to calculate how many pages of memory you're going to need, and thus can call GETBUFR for that space. e.g.:

```
    lda     #5              ;1K + 256 bytes (5 * 256 =
                            ;1280)
    jsr     getbufr         ;ask BASIC for the buffer
    bcs     error           ;oops, c=1 means error!
    sta     osysbuf+1       ;set OPEN param table buffer
                            ;to point to our buffer (for
```

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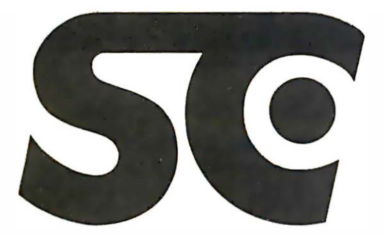
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```
                                ;the 1K File Control Block
                                ;[FCB])
     adc      #4                ;(carry is clear here) add 4
                                ;to that
     sta      rwdata+1          ;set READ param table to
                                ;point to just passed the
                                ;FCB. We'll have 256 bytes
                                ;to read/write.
     ldy      #0                ;set read/write count param
     sta      rwcount           ;zero least significant byte
                                ;($xx00)
     iny                        ;(y=1)
     sty      rwcount+1         ;set MSB ($01xx), --> $0100
                                ;= 256 bytes
```

This first asks BASIC for space for the File Control Block (needed when OPENing a file). Then it sets up the pointers for the OPEN and READ calls through the BASIC.SYSTEM Global Page tables. Onward...

```
     lda      #OPEN             ;($C8) Let's open the file
     jsr      gosystem          ;call big brother
     bcs      ferror            ;if error on OPEN, release
                                ;buffers
     lda      orefnum           ;successful open! Save
                                ;reference#
     sta      cfrefnum          ;...for CLOSE
     sta      rwrefnum          ;...for READ/WRITE
     lda      #READ             ;($CA) Let's read 256 bytes!
     jsr      gosystem
     bcs      fcerror           ;on error, close & free
                                ;buffers
```

At this point, you can manipulate the data that you just read. The address of that data is going to be stored at RWDATA ($bed7) in the BI global page, so you might want to copy the address into a zero page pointer for easy access. Now, for those errors:

```
fcerror   pha                   ;save the error code
     lda      #CLOSE            ;close the file
     jsr      gosystem
     pla                        ;retrieve error code
ferror    pha                   ;secondary entry if OPEN
                                ;fails
     jsr      freebufr          ;release those buffers
     pla                        ;accum now contains error
                                ;code
     jmp      errout            ;let BASIC handle this
```

If you are processing a text file for displaying, you might want to have special code check to see if the error is #5 (end of data), and if so, just close the file, but don't call ERROUT.

Hope all this helps.

PS: Almost forgot! When you want to remove your program from memory, do this:

```
     lda      mytop             ;restore the original HIMEM
     sta      $befb
     jmp      freebufr          ;remove my code's buffers
```

---

apple/language #414, from mdavis
a comment to message 412

Oops, I just found some bugs in my somewhat-long message with all that source code. (I typed it in on the fly in about 15 minutes.)

The part that sets the RWCOUNT parameter to $100 used "STA" instead of "STY".

Also, I never addressed what to do after you're done processing the file. First, obviously, you must CLOSE it. Second, you want to call FREEBUFR to deallocate the 5 pages of memory you originally asked for. Note that this won't trounce your code (which was protected by using an earlier GETBUFR call) because we changed the byte at $befb to point to the memory page where our code starts -- thus a FREEBUFR call will deallocate any buffers *below* that.

This has been really hard to explain. I found it all just by accident anyway since, as was stated earlier, the first release of the ProDOS Technical Ref. manual never covered this. The best thing to do is to experiment on your own, until someone writes a decent book on how to do this stuff.

---

apple/language #416, from jrsmith
a comment to message 412

Thanks for the tip. I *had* been doing something wrong; however, I still have a problem. I didn't understand that in addition to the 1K FCB, you need another buffer for your data. I had requested a 1K buffer and then pointed both OPEN and READ's buffer pointers to its start. Now I have pointed OPEN to a 1K buffer and READ to another 1K buffer below that. I still get my old enemy NO BUFFERS AVAILABLE (on OPEN).

Pagetop is set to right above the buffers, where my program begins. Nothing is marked in the system bit map that shouldn't be. Any other ideas?

---

apple/language #417, from mdavis
a comment to message 416

Ah! Yes; you must ask for buffers for both the OPEN file's FCB (1K worth) and then you need a second buffer area for reading and writing your data. (You can pick the size that you need; I just used 256 bytes in my example.)

If you use GETBUFR to allocate a 1K FCB, you also should use it to allocate a data buffer as well. You can use areas for reading and writing like $200 (the input buffer) since it's not reserved. You can usually get away with using BASIC's reserved 1K buffer space which it always maintains for its own use (like when it gets a CATALOG, or has to LOAD or SAVE a program, etc.).

Just keep playing with it, you'll get it. When you do, write a nice book for the those who are experiencing the same difficulties -- I'm just too darn busy!

ADA

Ada, the language mandated for most new programming by the Department of Defense, is coming under ever-closer scrutiny from microcomputer users. In the following excerpts from the Ada conference on BIX, various aspects of the language, from multiple definitions for operators to exception handling, are discussed.

PREDEFINED OPERATORS

ada/tips #1, from dshochat (David Shochat)

Here is a language point that I found kind of surprising. Maybe others will be surprised as well. Suppose you decide to define some types in a package:

```
package MY_TYPES is
  types FRUITS is (APPLE, GRAPE, PEAR);
    ....
end MY_TYPES;
```

Now you want to use type FRUITS someplace else, so you need a context clause:

```
with MY_TYPES;
```

Notice I didn't put in "use MY_TYPES;" Some people argue that for good maintainability, you"don't want to use 'use' all the time. This means that I need to prefix names defined in the package with the package name. So I declare:

```
FR1, FR2: MY_TYPES.FRUITS;
```

So far, so good. But now, in the executable part, I try to say:

```
    if FR1 = FR2 then
      ....
```

The compiler should give a message saying something like:

"The "=" operator is not defined for the objects FR1 and FR2."

It turns out that the "=" operator is what the LRM (Language Reference Manual) calls "predefined" by the definition of the type FRUITS. So, if it is predefined, why can't I use it? The answer is that it is predefined AT THE POINT WHERE TYPE FRUITS WAS DEFINED. It's just as if you had put your OWN "=" operator definition right in there with the definition of type FRUITS. So the moral is, there are some times when you really do have to use a 'use' clause, since the syntax won't let you say:

```
    if FR1 MY_TYPES.= FR2 then    -- Syntax error!
```

Interestingly, you CAN do it if you use prefix notation:

```
    if MY_TYPES."="(FR1, FR2) then   -- Perfectly legal!
```

But I don't think anybody would really want to do it that way. Actually, this problem is probably most likely to come up with access types (pointer types), but it's important to realize that it isn't a problem that is specific to access types.

(continued)

ada/tips #2, from rbrukardt (Randall Brukardt)

A similar problem to #1 here is that if you declare your own "&" operator, for instance (Function "&" (Left, Right : String) Return String;), it cannot be used infix outside of the declaring compilation unit.

If the above were to declare in a package specification, "A" & "B" used in the body would call the user-defined "&". But, if the same thing was written in some other package, the predefined "&" would be called, even if the declaring package was both WITHed & USEd! This follows from the Ada visibility rules; direct visibility always has precedence over something named in a USE clause.

Since the predefined "&" is always directly visible (it is declared in Standard, the package that surrounds all compilation units), the user-defined one can never be used in an infix expression outside of its defining package. It also must always be selected (i.e., Pack_Name."&"("A","B")) when it is used.

Moral: There's always a surprise awaiting you when you use (or implement) Ada.

VARIABLE-LENGTH RECORDS

ada/other #26, from rguilmette (Ron Guilmette)

What I would like to know from the other Ada vendors is how else can you write standard conforming programs that deal with variable-length record files? This would seem to be the most reasonable and clear approach. One question: What does DEC VAX Ada do when a variant record type is used to instantiate DIRECT_IO? Will it allow you to do it? If not, why not? If so, how can it perform reliable seeks on such files?

ada/other #28, from rbrukardt
a comment to message 26

Programs using variable-length records in a file are by definition not completely "standard-conforming," simply because such I/O is not REQUIRED by the standard. You hit on the problems of implementing it; I only wonder how anyone can figure out a workable way to implement it. (The interaction between Ada Generics, Discriminants, and I/O is horrible.)

I personally would recommend using a package of your own design to do such I/O; then, if the system you are using supports the I/O directly, the package is easy to write. Otherwise, a version of the I/O supported by the implementation can be used without too much trouble. (Of course, if the implementation gives you NO way to do variable-length records, it ought to be junked!)

ada/other #31, from dshochat
a comment to message 26

It turns out that DEC will let you instantiate DIRECT_IO with an unconstrained record type, but it requires you to pass a "maximum record size" in bytes through the FORM parameter of the CREATE procedure. The FORM parameter is of type STRING and its meaning is totally implementation-dependent. Anyway, it works, but it turns out that what they do in this case is really use fixed-length records, with the fixed length being what you passed in the CREATE. This is essentially what some Pascals do (e.g., UCSD) when you make a file of a variant record type. A fixed record size is used, big enough for the worst case.

ada/other #32, from rguilmette
a comment to message 31

Thanks for checking that out. It seems like a very nearly reasonable implementation; however, don't you think that a truly intelligent implementation would infer the maximum record length from the maximum length of the variant type used in the instantiation of DIRECT_IO? This is not a rhetorical question. I am interested in your thoughts.

ada/other #35, from dshochat
a comment to message 32

I agree with you in the case of a straight VARIANT record type. But consider something with a SIZE discriminant such as:

```
type VAR(SIZE : POSITIVE := 1) is
  record
    BUF : STRING(1..SIZE);
  end record;
```

If you tried to instantiate DIRECT_IO with that, the only thing the implementation could assume is that the maximum record size was POSITIVE'LAST (2**31 - 1 on the VAX) plus another 4 bytes for the discriminant. I've always thought it odd that a type definition like the one above doesn't have anyplace for you to commit to a maximum size. It must be hell to implement size discriminants.

EXCEPTION HANDLING

ada/general #82, from jdow (Joanne Dow)

How do you usually handle disk overflow deep in a program? The exception handling path allows you to recover gracefully (or as gracefully as possible) from that kind of error.
<^_^>

ada/general #84, from bhofkin (Bob Hofkin)
a comment to message 82

But you get kicked out of the code that faulted, with no simple way of restarting it. What would your exception handler look like for this disk overflow?

ada/general #85, from wheelock (Bruce Wheelock)
a comment to message 84

Disclaimer: I'm writing this from memory with my Ada manual elsewhere.

```
PROCEDURE FileOpener IS

     Flag : BOOLEAN := TRUE;
     FileName : ShortString      -- A defined type of
                                    length 30

BEGIN
     WHILE Flag LOOP
         BEGIN
             PUT_LINE("ENTER FILE NAME: ");
             GET_LINE(FileName);
             OPEN(MyFile,IN_FILE,FileName);
             Flag := FALSE;
         EXCEPTION
             WHEN OTHERS => PUT_LINE("File does not
             exist.  Try again.");
         END;
     END LOOP;
END;
```

With this construct, an error in the imbedded BEGIN/END block will raise an exception. The exception handler will display the message and exit the BEGIN/END block, which takes the program to the END LOOP. The WHILE condition is still true, so the loop repeats, prompting for the file name and trying to open it. It will keep this up, in fact, until a legal file is entered. A more complicated exception handler would offer the option to exit the procedure instead of trying again.

Satisfied? ■

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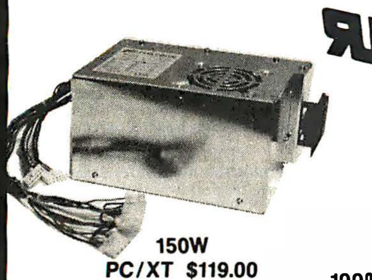
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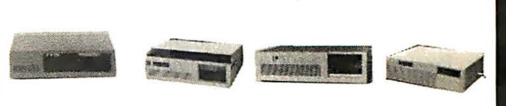
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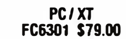


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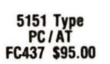






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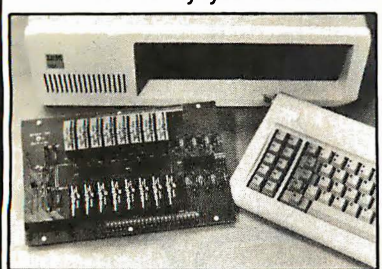
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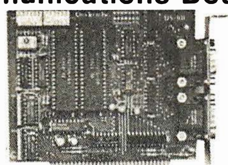
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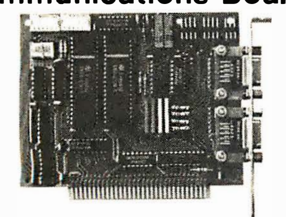
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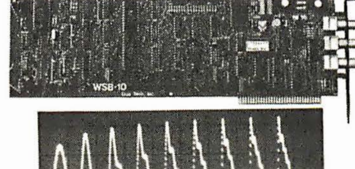
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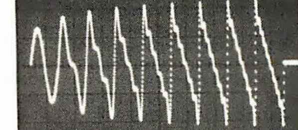
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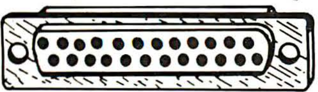
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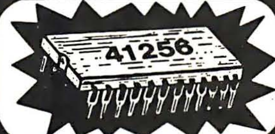


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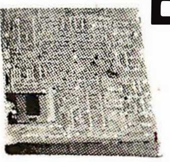
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Only 250 Available!

$129.95



Input Terminal:
Video In: RCA phone-jack
Audio In: Mini earphone jack
15½Hx17½Wx15½D"

Recommended Display: Character Number: 1700 Characters (64 Character x25 Rows on 5x7 Dot Matrix)

MOTOROLA 7" DIAGONAL SCREEN HIGH RESOLUTION GREEN SCREEN MONITOR

NEW! IN BOX

$280.00 Factory List

$29.95 4 for $99.00

MODEL MD1700

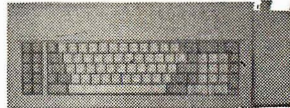
- Flat Faceplate
- 900 lines at Center 650 lines at corners.
- Operates from 12VDC at 1 Amp.
- Vertical input is 47 to 63 Hz.
- Horizontal input: 15.7 Khz (18.7 Khz optional)
- Video input signal: Positive white, input termination 470 ohms ± 5%, 2.5V to 5.0V P-P

Weight: 6lbs.

For split video (TTL Inputs) operation. Not composite video.

22 MHZ TYPICAL BANDWIDTH

INFRARED REMOTE CONTROL IBM PC/XT (OR JR.) KEY BOARD



LIQUIDATION! **$69.95** LIQUIDATION!

We are proud that we have been awarded the opportunity of offering these very unique keyboards. The original factory list was 259.00. We are blowing them out at an incredible price! Also, these are American made and not Taiwan clones. These can be operated by remote or attached to your computer.

COMPLETELY IBM COMPATIBLE

TEC MODEL 1550 PRINTER $279.00

- Centronics parallel and RS232 Serial ports
- 15" carriage
- 120 cps
- Tractor and friction feed
- Graphics



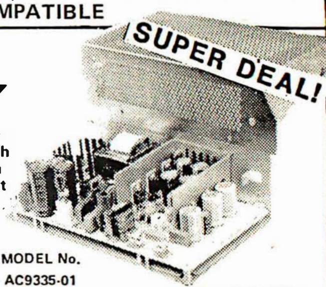
One of the largest manufacturers in the world has 125 of these prestigious printers in their overstock. We are extremely fortunate to be designated as their representative to market them.

ASTEC 65 WATT SWITCHING POWER SUPPLY

SUPER DEAL!

Dual input voltage 115/230 VAC - Overvoltage protection - Short circuit protection - Dual isolated +12V - Built-in EMI filter - Very compact size - UL/CSA/VDE approved - 100% thermal cycle & burn-in - High efficiency - Vaccum impregnated transformers - Convection cooling - Open PCB "L" bracket or boxed construction.

Dimensions: 8.0" - Length, 4.4" - Width, 2.4" - Height



SUPER DEAL! **$29.00**

OUTPUTS:

Condition No.1	Condition No.2
+5V DC@ 6.0A	+5V DC@ 5.0A(with two + 12V outputs in parallel)
+12V DC@ 1.5A	+12V DC(with two + 12V outputs in parallel)
+12V DC@ 2.1A	@3.5A (5.0A surge)
−12V DC@ 0.25A	−12V DC@ 0.25A

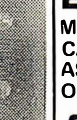
MODEL No. AC9335-01

PERFECT FOR POWERING:
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- FLOPPY DISK DRIVES
- MINICOMPUTERS
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PROGRAMMABLE SYNTHETIC SPEECH GENERATION BOARD

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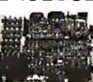


INCLUDES: Software and Speaker

EPSON QX-10

MOTHERBOARD WITH VIDEO CARD & YOUR CHOICE OF — ASCII KEYBOARD (ENCLOSED) OR HASCII (BARE)

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ONLY 250 SYSTEMS AVAILABLE!

Will work with any IBM compatible disk drive • CPU: μPD780AC-1 (Z80A compatible, 4 MHz) • Memory-RAM: 256K on board; Video RAM: 128K on CRT board; C-MOS RAM: 2K; EPROM: 2/4/8K (for IPL). Clock: C-MOS real-time clock. Interface: Serial and Parallel. DMA: 7 channels. Interrupt levels: 15; Counter/timer: 6 channels. Card slots: 5. Compatible with any TTL monitor. Weight: 10 lbs. with enclosed keyboard, 8 lbs. with bare keyboard.

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Model EFX 100T-3 100W • +5V @ 8A • -5V @ 1.5A • +12V @ 2.0A • -12V @ 2.0A • Input Voltage: 100 to 130Va-c or 200 to 260Va-c. 47-440 HZ Single phase. • Brownout Voltage: 90Va-c/180Va-c • Fused Input/Output protected against short circuit. Dim: 9⅜"L x 4¹⁵⁄₁₆"W x 2⅛"H. Weight: 3 lbs., Spec Included.

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5¼" DS/High Density
3.2 mByte Unformatted
2.3 Formatted
Takes 8" controller to operate

Wt: 4lbs.

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Linear Image Sensor $29.95

"The Twilight Zone"

Designed for page scanning applications including facsimile, (Optical Character recognition and other imaging applications which require high resolution and high sensitivity.

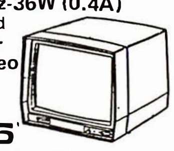
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REMEX FD480	59.95
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CENTRONICS Parallel Printer cable	12.95
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MODEL DM8112CX High Quality - Solid State 12" SANYO MONITOR

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AC 117V-60Hz-36W (0.4A)

Re-conditioned & fully tested - Composite video signal, sync. negative



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Video amp. bandwidth 18 MHz
Display format 1920 characters max. 80 char. x 24 lines (5 x 7 dot)
Scanning Frequency
Horizontal rate 15.75 KHz, Vertical rate 60 Hz
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UP TO 10 TIMES PC SPEED

$695.00



10 MHz

- Increases speed of PC/XT to make it 33% faster than an AT
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Minimum Order: $25.00. Shipping & handling charges via UPS Ground: $.50c/lb. UPS Air: $1.00/lb. Minimum Charge: $4.00. We accept cashiers checks, MC or VISA. No personal check COD's. Items reflect 5% cash or check discount. California residents add 6½% sales tax. We are not responsible for typographical errors. All merchandise subject to prior sale. Phone orders welcome. Foreign Orders require special handling. Prices subject to change without notice.

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5.25" DSDD - 96TPI(P/N38032).......71 ea.
5.25" DSDD -HD(P/N38042).......$ 1.36 ea.

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All prices quoted are for multiples of 100 each. Add 10% for orders of 50 each. All 5.25" diskettes are supplied with Tyvec™ sleeves, user ID labels and write-protect tabs. 3.50" diskettes are supplied with user ID labels.

Don't buy junk.

DISK WORLD!™ has always been the price and quality leader in diskettes.

Our SuperStar™ diskettes are fully certified to at least 65% clipping levels, far in excess of the ANSI and IBM™ standard of 40%.

Furthermore, SuperStar™ diskettes have jackets of at least 8-mils, as opposed to the 6-mil jackets offered by other low-priced brands. (And, believe us, jacket thickness makes a big difference in whether or not you will get read/write errors on your machine.)

SuperStar™ 3.50" diskettes are all licensed by Sony™ Corporation, the inventor of the 3.50" diskette standard, and meet their exacting standards.

All SuperStar™ diskettes carry a FULL LIFETIME WARRANTY against manufacturing and material defects.

Finally, all SuperStar™ diskettes are manufactured in the United States...not in Hong Kong, Taiwan, Pago Pago or other strange and exotic places where the standards of quality might not be quite as high.

In short, SuperStar™ diskettes are equal or superior to such famous brand names as 3m™, TDK™, Fuji™, Maxell™ and just about any other brand you can name!

SuperStar™ diskettes simply cost half as much or less.

The truth about diskette prices, brand names and some other unpleasant facts of life.

There are exactly two kinds of diskettes: good and bad.

The brand name...or absence of a brand name...on a diskette doesn't mean a thing in terms of quality.

Neither does the price.

For example, let's take a hard look at 3M™ diskettes, a brand which we have carried for more than three years.

During that time, we sold more than $ 6,500,000 worth of these diskettes...and that's one hell of a lot of diskettes.

Until very recently, we were proud to market 3M™ brand diskettes. Now we don't advertise them and actively discourage people from buying them.

Why?

Well, here's a quote from the July 21, 1986 Business Week magazine (page 107): "The disks have been plagued by quality problems recently..."according to one industry expert.

And a radical change in 3M's pricing policies has resulted in exactly the same diskette being sold at prices ranging from 29 to 89 cents, depending on who you were.

Not exactly a fair deal for anyone...except 3M™ which, according to Business Week earned a mere $ 73,000,000 in profits on magnetic media in 1985...mostly at your expense and ours while "(t)he diskettes have been plagued by quality problems recently..."

Counterfeiting and The Hong Kong Connection.

If the life of a diskette purchaser weren't bad enough already, there are now two more problems to contend with.

Counterfeiting is the newest game in town for the "let's get rich quick" crowd.

At least two mail order companies are currently operating very comfortable businesses offering "famous brand name" diskettes at unbeatable prices.

The prices ought to be unbeatable, since these two companies simply take an inferior diskette and slip into a Tyvec™ sleeve which they have printed to be an exact duplicate of the "famous brand name", slap on a forged manufacturer's label to the diskette and make a very tidy profit...without regard to the harm they are causing the end user.

Finally, there is now a wave of cheap, poorly made diskettes pouring in from the Orient, mostly Hong Kong. We are not talking about reputable brands such as Sony™ or Fuji™: we are talking about diskettes which are being turned out in sweatshops on outmoded equipment with little or no regard for quality control.

They show up in this country under a variety of names at extremely attractive prices. Prices so attractive, in fact, that your savings on buying these diskettes may just about pay for the cost of replacing your drives after you use them for a while.

90,000 DISK WORLD!™ customers really tell the story.

DISK WORLD!™ serves more than 90,000 customers throughout the United States and now the world. More and more major corporations, universities and governmental bodies have switched over to our SuperStar™ brands because they recognize that SuperStar™...with DISK WORLD!'s integrity standing behind it...offer absolutely the best combination of HIGH-QUALITY and LOW PRICE.

In short, DISK WORLD!™ and SuperStar™ are unbeatable.

Over the past three years, we've sold more than 30,000,000 diskettes.

Our return rate has been less than 1/10,000th of 1%.

Those two facts speak for themselves.

When every bit counts, it's SuperStar™!

We don't have to boast of imaginary factories employing "floppy phreaks", advertise diskettes for 39¢...if you buy 10,000 of them, offer "2 for 1" replacement guaranties or engage in any of the other hokum schemes designed to part you from your money.

Nor do we have to offer you "famous brand name" diskettes at inflated prices that don't offer you any more in quality, but do manage to support fleets of corporate jet aircraft and executive retreats in Minnesota and Canada.

We simply deliver the best for less.

More than a million diskettes a month flow out of our warehouse under the SuperStar™ "non-name". As noted, fewer than 1/10,000th of 1% of these are returned for any reason.

And that should say it all: SuperStar™ means far more for far less.

HOW TO ORDER:
ORDERS ONLY:
1-800-621-6827
(In Illinois: 1-312-256-7140)
INQUIRIES:
1-312-256-7140

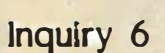
FOR FASTEST SERVICE, USE NO -COST MCI MAIL. Our address is DISKORDER. It's a FREE ,MCI MAIL letter. No charge to you. (Situation permitting, we'll ship these orders in 24 hours or less.)

SHIPPING: 5.25" & 3.50" DISKETTES-Add $ 3.00 per each 100 or fewer diskettes. **OTHER ITEMS:** Add shipping charges as shown in addition to other shipping charges. **PAYMENT:** VISA, MASTERCARD and Prepaid orders accepted. **COD ORDERS:** Add $ 5.00 special handling charge. **APO, FPO, AK, HI & PR ORDERS:** Include shipping charges as shown and additional 5% of total order amount to cover PAL and insurance. We ship only to United States addresses, except as shown above. **TAXES:** Illinois residents add 7% sales tax.

DISK WORLD!, Inc.

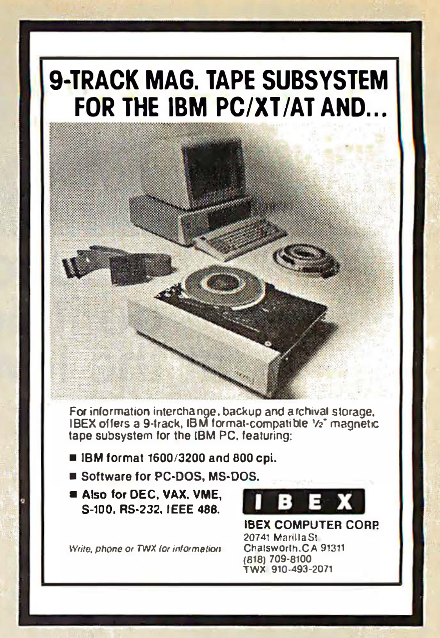
629 Green Bay Road
Wilmette, Illinois 60091



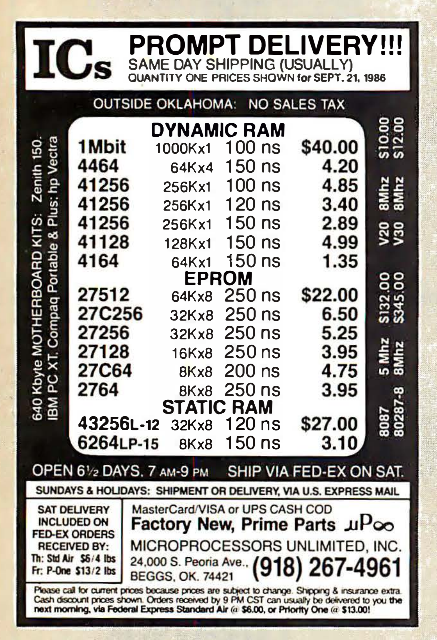

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Inquiry 293



Inquiry 155



Inquiry 216



Inquiry 341



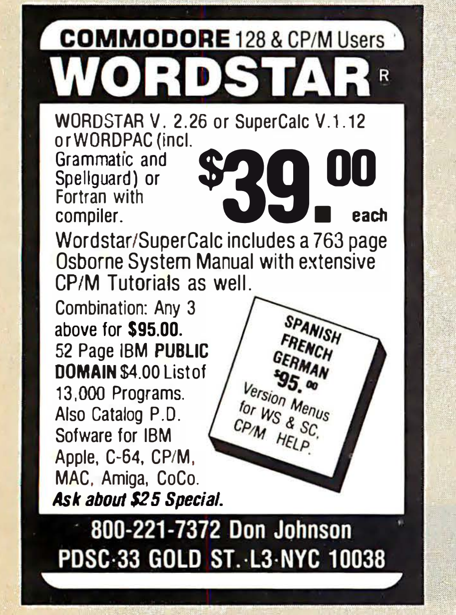


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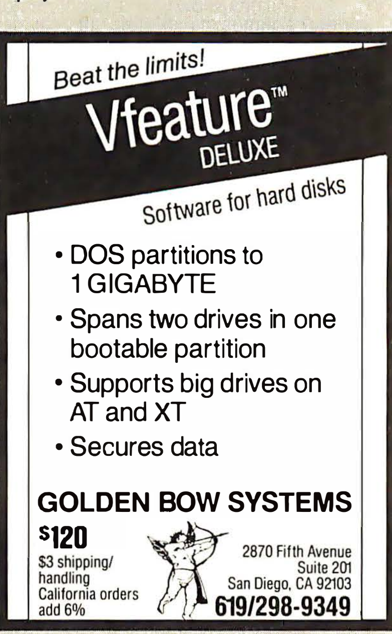
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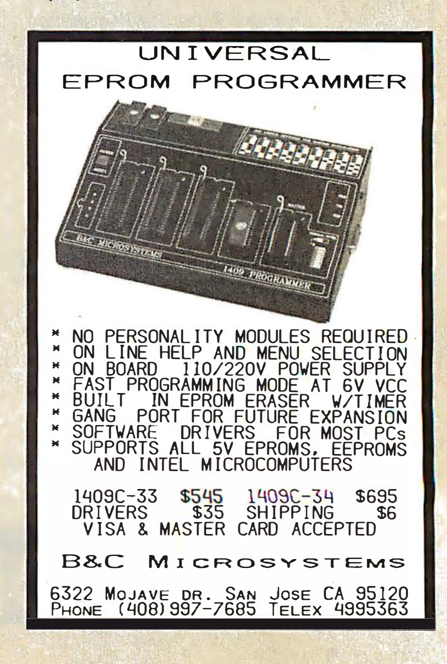
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Logic Array MegaCard!

NEW!

$499

- Hard disk drive on a plug-in card gives PC or compatible the storage capacity of an XT
- Uses NEC technology for high reliability
- Fast, easy installation
- **two year guarantee**—parts and labor

21-Megabyte $499
30-Megabyte . . . . CALL FOR PRICE

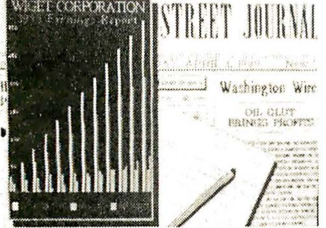
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(enables your PC or XT to read and write AT-formatted diskettes)
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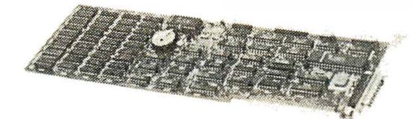
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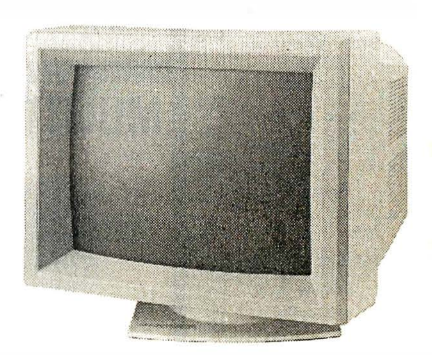
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Teac

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Item	Price
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Fujitsu

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Item	Price
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Western Digital controller card	$125

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Item	Price
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Item	Price
10MB INTERNAL TAPE DRIVE half height unit uses floppy controller	$499
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Alloy

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AST

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JRAM AT w/OK (Parallel 2MB capacity)	$190
JRAM 3 AT w/OK (EMS board, up to 2MB capacity)	$239

Clone Multi-Function

Item	Price
6 PACK compatible w/S, P, C, G, w/OK (up to 384K) w/software	$99

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Item	Price
DISK I/O operates 2 floppies, and G, S, P, C	$95
AT I/O, Parallel, Serial	$95

MODEMS

Hayes

Item	Price
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SMARTMODEM 1200 External (1200/300 baud)	$479
SMARTMODEM 2400 External (2400)	$630

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Item	Price
EVERCOM Modem (1200/300 baud w/software)	$150

US Robotics

Item	Price
COURIER 2400 Baud Internal or External	$491

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Alloy

Item	Price
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12 Slot Expansion Chassis 225 Watt power supply	$1135
20' RS-232 Slave Cable	$39
ATNX ALLOY TERMINAL NETWORK EXECUTIVE SOFTWARE	$295
LINK RS-323 ASCII Terminal IBM Keyboard	$625

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Citizen (Epson & IBM Compatible)

Item	Price
MSP-10 160/40 cps dot matrix narrow carriage	$307
MSP-15 160/40 cps dot matrix-wide carriage	$414
MSP-20 200/50 cps dot matrix-narrow carriage	$347
MPS-25 200/50 cps dot matrix-wide carriage	$520

Epson

Item	Price
FX-85 160 cps, narrow carriage NLQ	$434
FX-286 200 cps, wide carriage NLQ	$579
LQ 1000 24 Pin, 180 cps NLQ 60 wide carriage	$830
LQ 800 24 Pin, 180 cps, NLQ 60 narrow carriage	$630

IBM

Item	Price
Proprinter	$445
Proprinter XL Wide Carriage	$661

Okidata

Item	Price
ML182 120 cps narrow carriage	$228
ML 192 160 cps NLQ narrow carriage	$327
ML 193 160 cps NLQ wide carriage	$529
ML 292 200 cps 100 NLQ narrow carriage color	$614
ML 293 Dual 9 pin, 200 NLQ wide carriage color	$803
2410/P/IBM 350 cps 175/85/wide	$1850

Toshiba

Item	Price
P-351 24 pin 288 cps wide carriage	$989
P-341 24 pin 216 cps wide carriage 180 NLQ	$727
P-321 24 pin 216 cps narrow carriage	$442
P-351 C Color printer	$1178

Panasonic

Item	Price
KXP1091 120 cps, NLQ 29 cps	$270
KXP1092 180 cps, NLQ 33 cps	$348
KX1592 wide carriage, 180 CPS, NLQ 38 cps	$480

NEC

Item	Price
P-5XL24 pin, 290 cps, 100 NLQ color	$1071
P-6, P-7, 24 pin	$477/667

LASER PRINTERS

Hewlett-Packard

Item	Price
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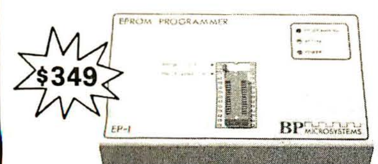
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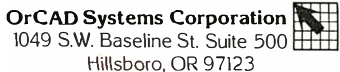
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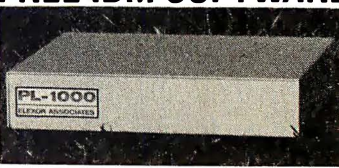
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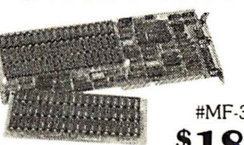
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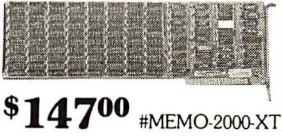


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Trans-Net 001 System: Network Interface Adapter, Utilities Software, Tap Box, 30 Feet of Trunk Cable (RS-422), Cable Terminators, Instruction Manual for Setting Up Basic Network System.

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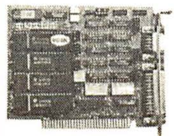
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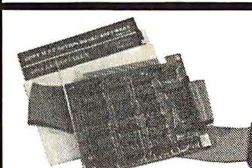
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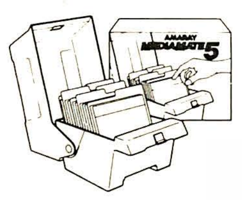
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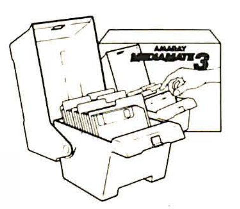
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7404	.35	.25	7489	2.05	1.95
7405	.39	.29	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.59	.49
7410	.35	.25	74125	.55	.45
7414	.49	.39	74126	.75	.65
7416	.45	.35	74143	4.05	3.95
7417	.45	.35	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.65	.55
7442	.55	.45	74175	.65	.55
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	2.05	1.95
7448	2.05	1.95	74193	.79	.69
7472	.75	.65	74198	1.85	1.75
7473	.45	.35	74221	.99	.89
7474	.45	.35	74273	2.05	1.95
7475	.49	.39	74365	.69	.59
7476	.45	.35	74367	.69	.59

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.79	.69
74LS30	.29	.19	74LS243	.79	.69
74LS32	.35	.25	74LS244	.79	.69
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
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74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
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74S08	.35	74S196	2.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.35	74S288*	1.49
74S124	2.95	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

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Part No.	Price	Part No.	Price
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74ALS02	.35	74ALS174	.89
74ALS04	.39	74ALS175	.89
74ALS08	.39	74ALS240	1.49
74ALS10	.39	74ALS244	1.49
74ALS27	.39	74ALS245	1.49
74ALS30	.39	74ALS373	1.69
74ALS32	.39	74ALS374	1.69
74ALS74	.49	74ALS573	1.69

74F

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74F04	.39	74F157	.95
74F08	.39	74F193	3.95
74F10	.39	74F240	1.39
74F32	.39	74F244	1.39
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CD4024	.49	CD4511	.69
CD4027	.35	CD4515	.89
CD4030	.29	CD4518	.75
CD4040	.65	CD4520	.75
CD4049	.29	CD4522	.79
CD4050	.29	CD4538	.79
CD4051	.59	CD4541	.69
CD4052	.59	CD4543	.79
CD4053	.59	CD4553	4.95
CD4059	3.95	CD4555	.79
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CD4066	.29	CD4572 (MC14572)	.39
CD4069	.25	CD4583	.89
CD4070	.25	CD4584	.39
CD4071	.25	CD4585	.89
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2102	1024 x 1	(350ns)	.89
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2114N-L	1024 x 4	(450ns) LP.	1.09
2114N-2	1024 x 4	(200ns)	1.05
2114N-2L	1024 x 4	(200ns) LP.	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	4.95
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6116LP-3	2048 x 8	(150ns) LP. CMOS	1.95
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6264LP-12	8192 x 8	(120ns) LP. CMOS	4.25
6264P-15	8192 x 8	(150ns) CMOS	3.59
6264LP-15	8192 x 8	(150ns) LP. CMOS	3.75
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TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	3.75
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2732A-25	4096 x 8	(250ns) 21V	3.95
2732A-45	4096 x 8	(450ns) 21V	3.75
27C32	4096 x 8	(450ns) 25V (CMOS)	6.49
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	4.25
2764-45	8192 x 8	(450ns) 21V	3.49
27C64	8192 x 8	(450ns) 21V (CMOS)	5.49
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27128A-25	16,384 x 8	(250ns) 12.5V	4.95
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-25	32,768 x 8	(250ns) 256K (12.5V)	5.95
27C256-25	32,768 x 8	(250ns) 256K(CMOS) (12.5V)	8.95
27512-25	65,536 x 8	(250ns) 512K(12.5V)	19.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
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14 pin WW	.65	.59	.55
16 pin WW	.69	.65	.59
24 pin WW	1.19	1.09	.99
28 pin WW	1.39	1.29	1.19
40 pin WW	1.89	1.69	1.55

— SOLDERTAIL STANDARD (GOLD & TIN) AND HEADER PLUG SOCKETS ALSO AVAILABLE —

SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interfaced and camera video recorder applications. **COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION**

MM5321 . . . . $11.95

DIGITALKER™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc. The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

Part No.	Description	Price
DT1050	Digitalker™	$24.95

DT1057—Expands the DT1050 vocabulary from 137 words to over 250 words. Includes two (2) ROMs and specs.

DT1057 . . . . $11.95

INTERSIL

Part No.	Price	Part No.	Price
FE0202D	12.95	7211IPL (TTL)	6.95
FE0203D	12.95	7211MIPL (Micro)	7.49
7106CPL	9.95	7216CIJL	29.95
7106EV/Kit	49.95	7216DIPL	24.95
7107CPL	11.95	7217IJL	10.95
7107EV/Kit	49.95	7217AIPL	9.95
7207AIPD	6.95	7224IPL	12.95
7207AEV/Kit	8.95	7226AEV/Kit	99.95

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	.99
74HC04	.29	74HC240	.79
74HC08	.29	74HC244	.79
74HC10	.29	74HC245	.89
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC393	.75
74HC85	.79	74HC595	1.19
74HC86	.39	74HC688	.79
74HC123	.89	74HC4040	.89
74HC125	.49	74HC4049	.59
74HC132	.49	74HC4050	.59
74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74C—CMOS

Part No.	Price	Part No.	Price
74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.49
74C08	.35	74C240	1.29
74C10	.35	74C244	1.29
74C14	.49	74C373	1.49
74C32	.35	74C374	1.49
74C74	.59	74C912	7.95
74C85	1.39	74C915	1.39
74C86	.35	74C920	9.95
74C89	5.19	74C921	9.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

Part No.	Price	Part No.	Price
DS0026CN	1.95	LF411CN	.79
TL074CN	.89	TL497ACN	2.69
TL084CN	.99	NE540H (C540H)	2.95
LM307N	.45	NE555V	.29
LM309K	1.25	XR-L555	.75
LM311N	.45	LM556N	.49
LM317T	.79	NE558N	.89
LM318N	.99	LM565N	.99
LM319N	.99	LM567V	.79
LM320K-5	1.35	NE592N	.89
LM320T-5	.59	LM741CN	.29
LM323K	3.95	LM747CN	.59
LM324N	.39	MC1377P	4.95
LM338K	4.95	MC1398P	8.95
LM339N	.39	LM1458N	.39
LM340K-5	1.29	LM1488N	.49
LM340K-12	1.29	LM1489N	.49
LM340K-15	1.29	LM1496N	.85
LM340T-5	.49	LM1871N	2.95
LM340T-12	.49	LM1872N	2.95
LM340T-15	.49	LM1896N-1	1.59
LF347N	1.79	ULN2003A	.99
LM348N	.69	XR2206	3.95
LF351N	.39	XR2211	2.95
LF353N	.49	XR2243	1.95
LF355N	.79	LM2907N	2.49
LF356N	.79	LM2917N (8 pin)	1.55
LM358N	.49	LM3900N	.49
LM360N	2.19	LM3905N	1.19
LM361N	1.79	LM3909N	.99
LM380N-8	.99	LM3914N	1.95
LM386N-3	.99	LM3916N	1.95
LM387N	.99	NE5532	.89
LM393N	.39	NE5534	.69
LM399H	2.95	75477	1.29
		76477	5.95

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Inquiry 165

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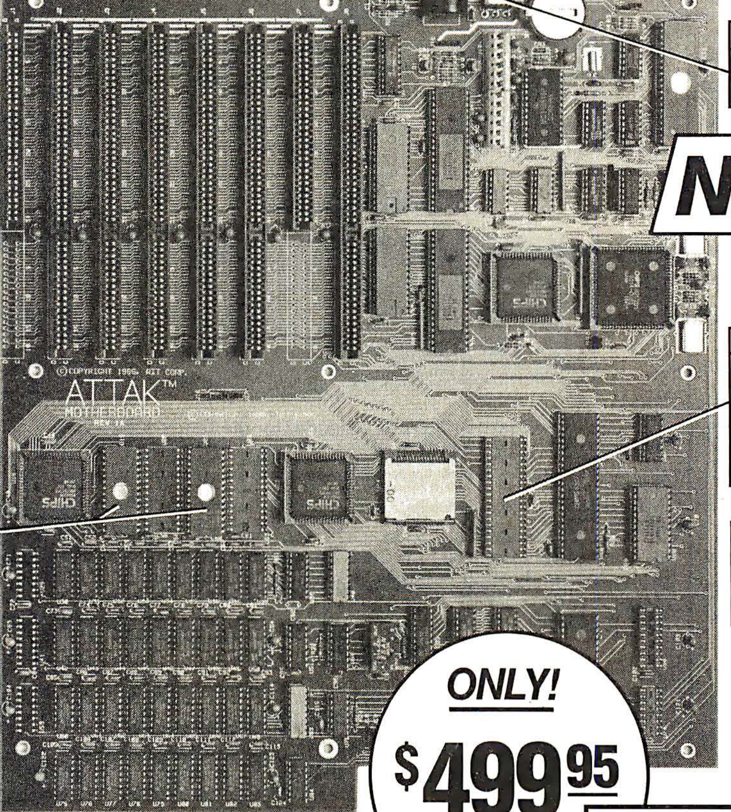
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Inquiry 8

California Digital

17700 Figueroa Street • Carson, California 90248

IBM Compatible Computer



- 256K Expandable to 640K on Motherboard
- Double Sided Double Density Disk Drive
- IBM Type Keyboard (with LED indicators)
- Floppy Controller Card
- Eight Expansion Slots
- 135 Watt Power Supply

The Eclipse 16 is an outstanding value in IBM Compatible Computers. After careful research and evaluation we found it to be the most reliable unit.

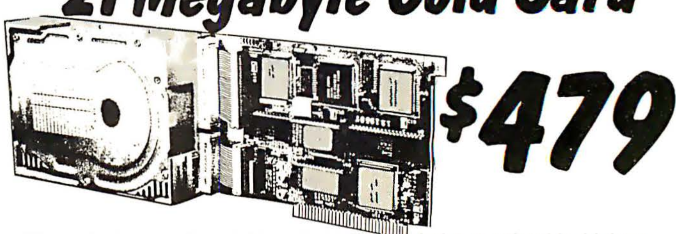
Our computer includes some of the newest features available, such as the 4.7MHz, multi-layer motherboard with 256K of RAM upgradable on board to 640K. A generous eight expansion slots and 135 Watt power supply give you ample room and power for add-on boards. The enclosure has an easy-access flip top lid making upgrades a breeze. And our floppy controller supports up to four drives, so as many as three additional drives can be used. Finally, each computer is configured and fully tested before sending it to you.

Satisfaction Guaranteed! We're really excited about this new unit, and so sure you will be too... that you may return the Eclipse 16 for a full credit towards an IBM PC if you are not completely satisfied.

OPTIONS

Option	Price
20MB Hard Drive w/Controller	$495
Additional Drive-Installed	99
Irwin 10 Meg. Tape Back up	489
Upgrade from 256K to 640K RAM	79
8087 Math Co Processor	119
Color Graphics Card	79
Monochrome Graphics Card	99
RGB Color Monitor	199
TTL Monochrome Monitor	139
Microsoft Mouse	139
Upgrade from Floppy Controller to Disk I/O 2 drive controller, clock/cal., software parallel, serial, and game ports	79
1200 Baud Internal Modem w/Software	179

21 Megabyte Gold Card



The fastest, lowest powered, longest warrantied, most durable, highest capacity, most reliable, lowest priced HARD-DISK-ON-A CARD available in the world today.

• 65ms Access Time - *Fastest Available* • Automatic Head Unloading - *Protects Heads and Media* • 2K Sector Buffer - *Increases System Throughput* • High Reliability: 28,000 hr. MTBF - *No one else even close* • 15.5 Watt Power Consumption - *Lowest Available* • 2 Year Warranty - *Longest Available*

WERE $695... GET 'EM WHILE THEY LAST FOR JUST $559 $479

NOW YOUR COMPUTER CAN READ!!

Omni-Reader... the first optical character reader **designed and priced for the small computer**

$179



COPY:
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APPLICATIONS:
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Uses a standard RS-232 serial port hookup to interface eaisily with your computer.

1200 BAUD MODEMS

AVATEX 1200 $99



This 300/1200 baud modem matches the design specs of the Bell 212A, feature by feature, bringing you reliability, impeccable transmission and easy operation. Hayes Compatible, except for "S" register. Communication software included.

The AVATEX 1200, at $99, is a steal!

SMARTEAM 1200 $159



The Team 212A offers all the features of the Hayes Smart Modem 1200 for a fraction of the price. Now is your opportunity to purchase a 1200 baud modem at the price of a 300 baud modem.

ECLIPSE 2400 BAUD MODEM $299





- Hayes & Bell 212A/103 Compatible
- CCITT V.22, V.22 bis

The ECLIPSE 2400 modem is a microprocessor-based full or half-duplex modem incorporating the latest in high speed data communications capabilities. It also accomodates computers and terminals equipped with an RS-232 port allowing communication with other computers or timeshar ing systems either locally or remotely. Compatibility, Versitility and Performance are yours in a configuration designed to provide years of reliable operation.

NEC RACKMOUNT MODEM $69



The NEC N212BR modem is designed for use in a rackmount configuration or may be used stand alone on external power. The Unit is fully 300/1200 Hayes compatible allowing for auto dial, auto log/on password capabilities. This modem is also switch selectable to the special NEC command set, which contain too many features to describe in this limited space.

The NEC212BR originally cost $595. California Digital has available 500 units which we are offering at only $69.

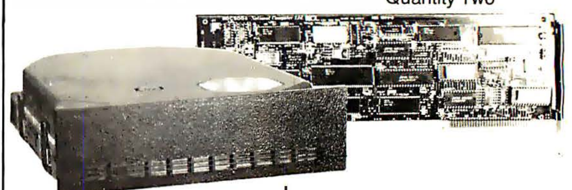
MODEMS

Description	Part No.	Price
Eclipse 1200 100% Hayes, with status lamps.	EDP-1200	149.00
Eclipse 1200B internal with software	EDP-1200B	139.00
Eclipse 2400 External, Hayes Compatiple	EDP-2400	299.00
Avatex 1200 baud external, Hayes	AVA-1200	99.00
Hayes Smartmodem 2400 baud modem	HYS-2400	599.00
Fujitsu 2400/1200 baud auto everything.	FUJ-1935D	459.00
Team 1200 Hayes Compatible, 300/1200 baud.	TEM-1200	159.00
Smarteam 1200B IBM 1200 baud card	TEM-1200B	159.00
UltraLink 1200 data and voice on same line.	UTL-1200A	99.00
CTS 212AH 1200 baud, auto dial	CTS-212AH	179.00
Terminal software for CTS 212AH	CTS-212SFT	35.00
Prometheus 1200 super features	PRM-P1200	289.00
Prometheus 1200B internal PC	PRM-P1200B	279.00
Signalman Mark VI, 300 baud internal PC	SGL-MK6	49.00
Hayes Smart Modem 1200 baud, auto dial	HYS-212AD	369.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	339.00
Hayes Chronograph, time & date	HYS-CHR232	199.00

Seagate $299

20 MEGABYTE WINCHESTER HARD DISK DRIVE

Quantity Two



Five Inch Winchester Disk Drives

Drive	each	two+
SEAGATE 225 20 Meg. ½ Ht.	329	299
SEAGATE 4026 26 M. 35mS.	759	729
SEAGATE 4051 51 M. 35mS.	995	959
FUJITSU 2242 55 M. 35mS.	1599	1529
FUJITSU 2243 86 M. 35mS.	2095	2019
RODIME RO-202E 27 Meg.	659	629
RODIME RO-203E 40 Meg.	995	959
RODIME RO-204E 53 Meg.	995	959
CONTROL DATA 94155-86 M.	1829	1779
MAXTOR XT1140 140 Meg.	2995	2929
HONEYWELL 85M. 27 mS.	1795	1695
TOSHIBA MK5670 M. 30mS.	1789	1729
TANDON 502 10 Meg.	419	379

Item	Price
• Winchester Controllers for IBM/PC •	
XEBEC 1220 with floppy controller	229
DTC 5150BX	139
OMTI 5510 half card	139
ADAPTEC 2070 RLL controller	189
ADAPTEC 2010A	169
WESTERN DIGITAL WD/1002	139
• SCSI/SASI Winchester Controllers •	
XEBEC 1410A 5¼" foot print	219
OMTI 20L	119
• Winchester Accessories •	
Installation Kit with manual	10
Winchester enclosure and supply	139
Dual 20/34 cable set	25
Switching power supply	49

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CHERRY INFRARED KEYBOARD



$119

The Cherry Switch Infrared wireless 84 key keyboard designed for use with the IBM/PC and XT serries computers. The keyboard operates similar to the remote tuner of modern televisions, and transmits 20 feet line of sight to the computers IR receiver.
This wireless keyboard is ideal for classroom demonstrations or for use with projection screen television monitors. Includes IR keyboard and receiver module. Manufacturers suggested list was $289 now available, while they last for only $119.

Bernoulli Box

was $3540 now only

$1595



The Bernoulli Box by Iomega, features 10 and 20 megabyte removable cartridges, and delivers reliability, expandability, transportability, security and speed in one versatile subsystem. It lets you transfer megabytes of information safely and swiftly for primary or backup storage. Or combine several software programs onto a single cartridge for easy switching from one to another.
Reliable... the Box has incredible resistance to shock and vibration completely eliminating the possility of head crash.
Expandable... grow at your own pace by adding inexpensive cartridges. When **security** is essential, don't lock up your system... just lock up the cartridges.
The Bernoulli Box delivers preformance that often exceeds the best of hard disk speed and the convenience of floppy disks. At these prices don't be caught wishing you had one after a loss of irreplacable data.

		List	Our Price
10+10 Meg.	A2210H	$3450	1595
20+20 Meg.	A2220H	4540	2095
Bootable Controller		255	159
10 Meg. Cartridge		79	49
20 Meg. Cartridge		99	65

PRINTERS

MATRIX PRINTERS

NEC/P7 132 col., par'l interface.	NEC-760	659.00
Star Gemini NL-15, 300cps., 136 col.24 wirehead	STR-NB15	389.00
Star Gemini NX-10, 120 cps/30 cps NLQ, tractor	STR-NX10	359.00
Citizen MSP/10FT 160 char/sec.	CIT-MSP10	259.00
Panasonic KX1091 120 cps. draft, 29 NLQ tract & friction.	PAN-KX1091	259.00
Toshiba 351P/S, 240 char/sec. 24 wire head	TOS-351 PS	1099.00
Toshiba 341 PS/E parl. 180 cps. 24 wire head	TOS-341PSE	759.00
Okidata 182P/IBM parallel 9½" paper	OKI-182P	239.00
Okidata 192A parallelinterface, 160 char/sec.	OKI-192A	379.00
Okidata 84P parallel 15" paper	OKI-84P	695.00
Epson LX-80 10" 120 Char/sec.	EPS-LX80	259.00
Epson LQ800 near letter quality	EPS-LQ800	629.00
Epson FX85 160 cps. draft 32 cps. NLQ, 240 dot/inch.	EPS-FX85	399.00
Epson FX286 132 col., 200 cps. 29 cps NLQ, graphics.	EPS-FX286	599.00
Dataproducts B-600-3, band printer 600 LPM	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines oer minute	PTX-P600	5795.00

WORD PROCESSING PRINTERS

Starwriter F10 (6400) parallel. 40 char/sec.	PRO-F10P	429.00
Same as above but 55 char/sec., 50 pin Diablo interface	PRO-F55P	559.00
NEC8810 55 char/second, serial interlace	NEC-8810	1179.00
NEC8830 55 char/sec, par'l interface.	NEC-8830	1179.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	819.00
Silver Reed EXP600, 25 cps. 10/12/15 pitch, serial/par'l.	SRD-EXP600	319.00
Silver Reed EXP800 same as 600 but 40 char/sec.	SRD-EXP800	72900
Diablo 620, proportional spacing, horz.& vert. tab. 20 cps	DBL-620	299.00
Juki 6100, 18 char./sec.	JUK-6100	359.00
Juki 6300, 40 char./sec.	JUK-6300	689.00

Quick-Link 300



$59

The Quick-Link 300 gives you an instant link to any dial up data base. Such as Dow Jones, Western Union or the Source. The Quick-Link has four user programmable log-on keys, allowing the operator, with only one keystroke, to dial the data base, log-in and give the password. All this information is permanently stored in non-volatile RAM.
Features include video output to television or monitor, auto dial, auto-log, full sized keyboard, 300 baud modem and 1200 baud auxillary printer port. All this is available for only $59.



FOUR PEN COLOR PLOTTER

$159

The manufacturer has asked us not to publish their name. But this four color plotter was produced by one of the Worlds largest makers of personal computers.
The 410 color plotter will connect to the serial port of virtually any micro-computer. Simple ASCII commands direct one of the four color pens to draw circles, arcs or ellipses on paper or transparency material up to 11 by 17 inches. The plotter is capable of producing the full upper and lower case alphabet along with seven international character sets. Text can be printed horizotal, vertical or diagonal in sizes from 1/16 to 6 inches, slanted forward or backward to 85 degrees.
Enlargements or reductions are achieved through elaborate firmware. Pen travel is four inches per second with .004" pen resolution. Standard pens are available in an assortment of 32 different colors and widths.
The ideal plotter for architecture, CAD engineering or graphic design. **At $595 it was a great buy, at $159 its a steal.** Support packages for specific computers available. Manual only $15 refundable upon purchase or plotter.

PLOTTERS

Four pen color plotter, 11 by 17 IBM/PC compatible	APL-410	$159
Sweet "P" 100 (Comrex) 8½ by 120"	COM-C1	$159
Houston Instruments DMP29, 11 by 17	HOU-29	1779
Houston Instruments DMP40, 11 by 17, B size	HOU-40	959
Houston Instruments DMP41/42 C/D 24 by 36	HOU-41	3779
Houston Inst. DMP51/52MP C/D, 14 pen plotting	HOU-51MP	4859
Houston Instruments DMP56, E size 34 by 44	HOU-56	4795
Houston Instruments PC695, 11 by 17 multi-pen	HOU-695	579
Roland DYX-101 flatbed 11 by 17	ROL-101	419
Roland DYX-800 11 by 17 multi-pen 8 color	ROL-800	899
CalComp 1043GT plotter	CCP-1043	7899
DIGITIZERS • MOUSE		
Hitachi Tiger Tablet 11 by 11"	HIT-TT2	615
Summagraphics Summasketch 12" fourbutton	SUM-SK12	399
Summagraphics SummaMouse 100 line resolution	SUM-MS	99
MicroSoft serial mouse with paint brush	MST-MS232	139
MicroSoft bus mouse card w/paint brush	MST-MSB	129



XEROX Sunrise Computer

$299

The Xerox Sunrise 1810 is by far the best value we have ever seen in a micro computer. This is a self contained battery and AC portable. The Sunrise was originally prices at $2995. Xerox has since elected to drop the computer from their product list. California Digital has purchased all the remaining inventory and is making the unit available at a fraction of its original cost.
This portable features a built in 80 column liquid crystal display, 64K of memory along with both RF monitor and television outputs. The internal 300/1200 baud modem includes an auto dial telephone assembly. The units has both centronics parallel and a serial port programmable to 19,200 baud. The self contained micro cassette is capable of capturing data from the keyboard as well as doubling as an recorder for dictating messages.
An optional dual floppy disk drive module, pictured above, is available for only $219. Also available, for $59 is an 80 column printer that mounts in the drive module. The Sunrise features a CP/M operating system which allows the operator to use any CP/M program in Xerox 5¼" disk format and over 5000 CP/M programs available in public domain.

Dragon Computer

$89

Compatible with most Radio Shack Color Computer software. The world famous Dragon computer is now available in the United Stat s. Manufactured by the Tano Corp. under license of the British Broadcasting Company.
The Dragon comes complete with 64K Byte of memory, serial modem port along with a Centronics printer interface. This unique microcomputer features Motorola's advanced 6809E microprocessor and comes standard with Microsoft Color Basic, data base manager, and a complete word processing package. The computer outputs color composite video along with R.F. video that allows the unit to be used in conjunction with any color television.
This is the ideal low cost computer to be used with any dial up information system such as the Source, EasyLink or any other time share service.



RGB Color Monitor

$199

The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White.
The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these "new" RGB monitors at a fraction of their original cost. IBM/P/C Computer compatible NEC-1401/PC
Also available 12" Amdek Color 1 composite $159.

SONY 53W Floppy Disk Drive

3 1/2" New IBM portable compatible

$139

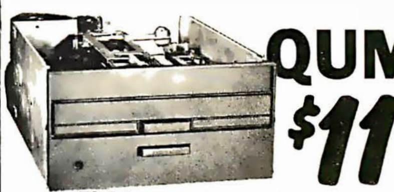


5¼" DISK DRIVE



$89 Quantity Two

	One	Two	Ten
TEAC FD55BV half height	109	99	89
TEAC FD55FV 96 TPI, half ht.	119	109	105
TEAC FD55GF for IBM AT	169	159	155
PANASONIC 455 Half Height	109	99	89
PANASONIC 465 ½ Ht. 96TPI	139	129	125
TANDON 100-2 full height	129	125	119
MITSUBISHI new 501 half ht.	129	119	109
MITSUBISHI 504A AT comp.	169	159	155
QUME 142 half height	99	89	89
Switching power supply			49
Installation Kit with manual			10
Dual enclosure for 5¼" drives			59
34 pin edge connectors			5
Scotch head cleaning kit			19
Flip & File Storage tubs			15



QUME

$119

Eight Inch Single Sided Drives			
QUME 841 single side	129	119	call
SHUGART 801R	359	359	354
SIEMENS FDD 100-8	119	115	109
Eight Inch Double Sided Drives			
QUME 842 "QUME TRACK 8"	189	179	call
SHUGART SA851R	495	485	475
OLIVETTI double sided	189	179	159
REMEX RFD-4000	179	169	159
MITSUBISHI M2896-63 ½ Ht.	459	449	409
Dual 8" enclosure with power and fan			259
Switching power supply			89
Installation kit with manual			10

Adeus Daisy Wheel

$159



The Adeus CP/2000, is a 22 character per second daisy wheel printer which accepts 96 character Diablo wheels and ribbons. This printer was manufactured by the Olympia Typewritter Company for Cosmo World USA.
This unit will print 10, 12 and 15 characters per inch proportionally spaced with increments of 1/120". Bi-directional printing, 2 K/Byte buffer (expandable to 6K) and both serial and Centronics parallel interfacing make the Adeus CP/2000 an exceptional buy at only $159. Original price $595.



Shipping: First five pounds $3.00, each additional pound $.50.
Foreign orders: 10% shipping, excess will be refunded.
California residents add 6½% sales tax. • COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a strong "Dun & Bradstreet" rating.



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INTERNATIONAL, INC.

- IBM PC PACKAGE Dual Floppy $995
- 64k RAM CHIPS set of 9 $8
- LOTUS SIGNAL $350
- IBM/APPLE/HARDWARE/SOFTWARE/ASK US!

▶▶▶ BOARDS ◀◀◀

- PARADISE EGA $350
- EVEREX Graphics Edge $235
- AST 6 PackPlus $150
- AST Rampage 256k $306
- HERCULES Graphics Card $179

▶▶▶ DRIVES ◀◀◀

- SEAGATE 20m w/PCXT controller $385
- SEAGATE 30meg XT 40ms/FAST $439
- MOUNTAIN 20meg Hardcard $739
- PC/AT 30 meg/38msec. $439

▶▶▶ PRINTERS ◀◀◀

- CANON LaserJet A-1 $1850
- EPSON FX286 $489
- OKIDATA 192/193 $339/459
- IBM PROPRINTER/XL $399/609

▶▶▶ MODEMS ◀◀◀

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- SUPERMODEM 1200 (Hayes comp.) $149
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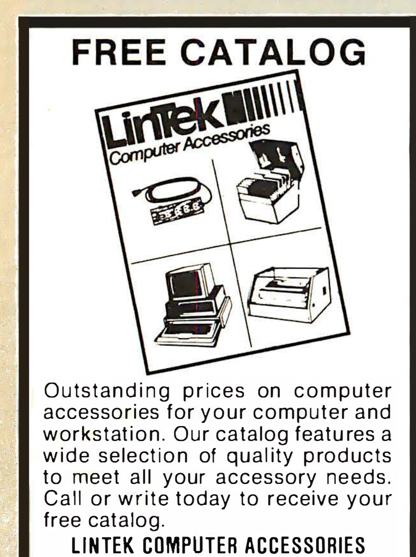


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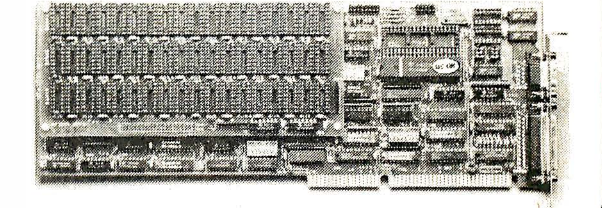
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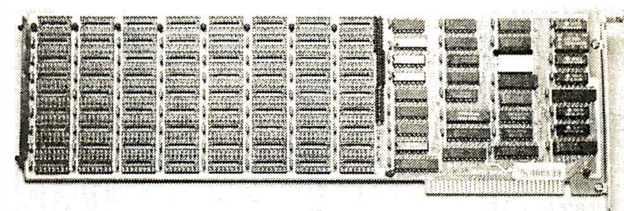


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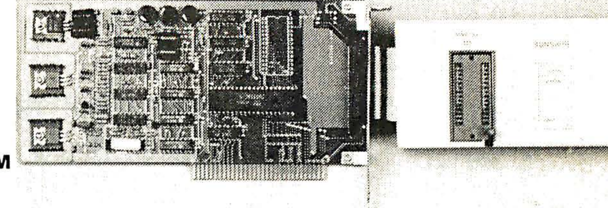
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2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
TMM2016-150	2048x8	(150ns)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM6116-4	2048x8	(200ns)(CMOS)	1.89
HM6116-3	2048x8	(150ns)(CMOS)	1.95
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.95
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	2.05
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49

LP=Low power

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Part	Org.	Spec.	Price
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4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5v)	1.19
4164-150	65536x1	(150ns)(5v)	1.29
4164-120	65536x1	(120ns)(5v)	1.95
MCM6665	65536x1	(200ns)(5v)	1.95
TMS4164	65536x1	(150ns)(5v)	1.95
4164-REFRESH	65536x1	(150ns)(5V)(REFRESH)	2.95
TMS4416	16384x4	(150ns)(5v)	4.95
41128-150	131072x1	(150ns)(5v)	5.95
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2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
27C64	8192x8	(250ns)(5V)(CMOS)	5.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.95
2764-200	8192x8	(200ns)(5V)	4.25
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27C256	32768x8	(250ns)(5V)(CMOS)	10.95
27256	32768x8	(250ns)(5V)	7.49

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PE-24T	YES	12	9,600	$175.00

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8087	129.00
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8088-2	9.95
8155	2.49
8155-2	3.95
8748	7.95
8755	14.95
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Part	Price
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8205	3.29
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8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.89
8253	1.89
8253-5	1.95
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8259-5	2.29
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6.0 MHz

Part	Price
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1.0 MHz

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2.0 MHz

Part	Price
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3.0 MHz

Part	Price
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6800

1.0 MHz

Part	Price
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2.0 MHz

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2.0	1.95
2.097152	1.95
2.4576	1.95
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3.579545	1.95
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4.032	1.95
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5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
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2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
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74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
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74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
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74LS147	.99	74LS670	.89
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74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
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74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
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74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
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74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
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74HCT158	.99	74HCT4017	2.19
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74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
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TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges - please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale.

   Inquiry 168

20MB HARD DISK SYSTEM ONLY $389.95!

CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	2.49
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	12.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.49	74S196	2.49
74S30	.29	74S197	2.95
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.59	7905K	1.69
7812K	1.39	7912K	1.49

TO-93 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM328K	Adj.	5A	TO-3	3.95
78H05K	5V	5A	TO-3	7.95
78H12K	12V	5A	TO-3	8.95
78P05K	5V	10A	TO-3	14.95

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49

ST=SOLDERTAIL

8 PIN WW	.59	.69
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80

WW=WIREWRAP

16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see 7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see 7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

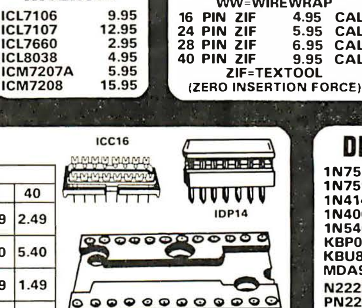
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00

MTG HDWR · HOOD25 · DB37S · IDB37S

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT 10 POSITION 6 PIN DIP		1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE

IDS34 · IDE50

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS



5/$1.00

Dear Mr. Rose:

I feel compelled to commend you and your people for the pleasant, polite, willingness to help and professional attitude you have displayed. In these times it is indeed refreshing to deal with a company whose staff consists of people of this caliber. My friends and associates will most certainly be doing business with you again.

Sincerely, Nicholas Chabra

CALL FOR VOLUME QUOTES

20MB HARD DISK SYSTEM ONLY $389.95!

BARGAIN HUNTERS CORNER

20 MEG FULL HEIGHT HARD DISK DRIVE

INCLUDES CABLE & CONTROLLER CARD

$349.95

SPECIAL ENDS 12/31/86

PAGE WIRE WRAP WIRE

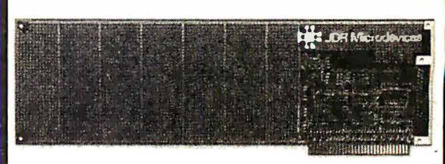
PRECUT ASSORTMENT
IN ASSORTED COLORS $27.50
100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

SPOOLS
100 feet $4.30 — 250 feet $7.25
500 feet $13.25 — 1000 feet $21.95

Please specify color: Blue, Black, Yellow or Red

WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE WITH GOLD-PLATED EDGE-CARD FINGERS



IBM-PR2

IBM

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
IBM-PR2	AS ABOVE WITH DECODING LAYOUT	$29.95

S-100

P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

EMI FILTER $4.95

- MANUFACTURED BY CORCOM
- LOW COST
- FITS LC-HP BELOW
- 6 AMP 120/240 VOLT

6 FOOT LINE CORDS

LC-2	2 CONDUCTOR	.39
LC-3	3 CONDUCTOR	.99
LC-HP	3 CONDUCTOR W/STD FEMALE SOCKET	1.49

MUFFIN FANS

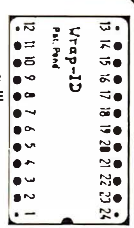
3.15" SQ	ROTRON	14.95
3.63" SQ	ETRI	14.95
3.18" SQ	MASUSHITA	16.95

SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC; SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6VAC CT	2 AMP	5.95
12.6VAC CT	4 AMP	7.95
12.6V AC CT	8 AMP	10.95
25.2V AC CT	2 AMP	7.95

25 PIN D-SUB GENDER CHANGERS



$7.95

SWITCHING POWER SUPPLIES

PS-IBM $69.95

- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY

PS-IBM

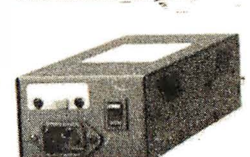
PS-IBM-150 $79.95

- FOR IBM PC-XT COMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A -12V @ .5A, -5V @ .5A
- ONE YEAR WARRANTY

PS-130

PS-130 $99.95

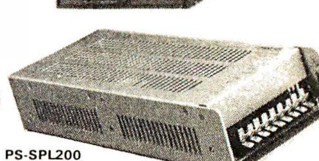
- 130 WATTS
- SWITCH ON REAR
- FOR USE IN OTHER IBM TYPE MACHINES
- 90 DAY WARRANTY



PS-A

PS-A $49.95

- USE TO POWER APPLE TYPE SYSTEMS, 79.5 WATTS
- +5V @ 7A, +12V @ 3A -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR



PS-SPL200 $49.95

- +5V @ 25A, +12V @ 3.5A -5V @ 1A, -12V @ 1A
- UL APPROVED
- ALUMINUM ENCLOSURE

PS-SPL200

CAPACITORS

TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

DATARASE EPROM ERASER $34.95

- ERASES 2 IN 10 MINUTES
- COMPACT-NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

1/4 WATT RESISTORS

5% CARBON FILM ALL STANDARD VALUES FROM 1 OHM TO 10 MEG. OHM

10 PCS	same value	.05	100 PCS	same value	.02
50 PCS	same value	.025	1000 PCS	same value	.015

RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	.69
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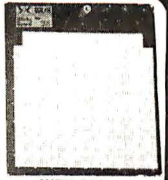
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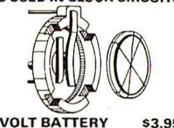
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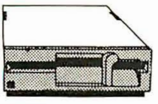
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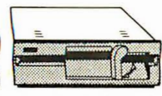
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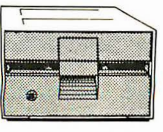
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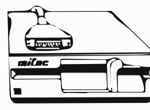


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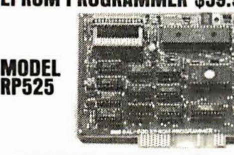
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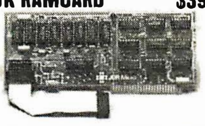
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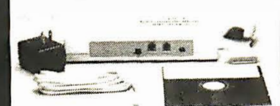
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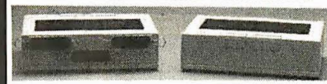
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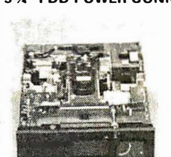
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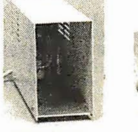
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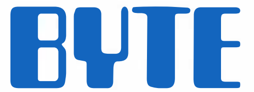
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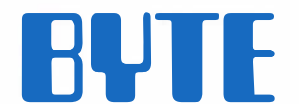
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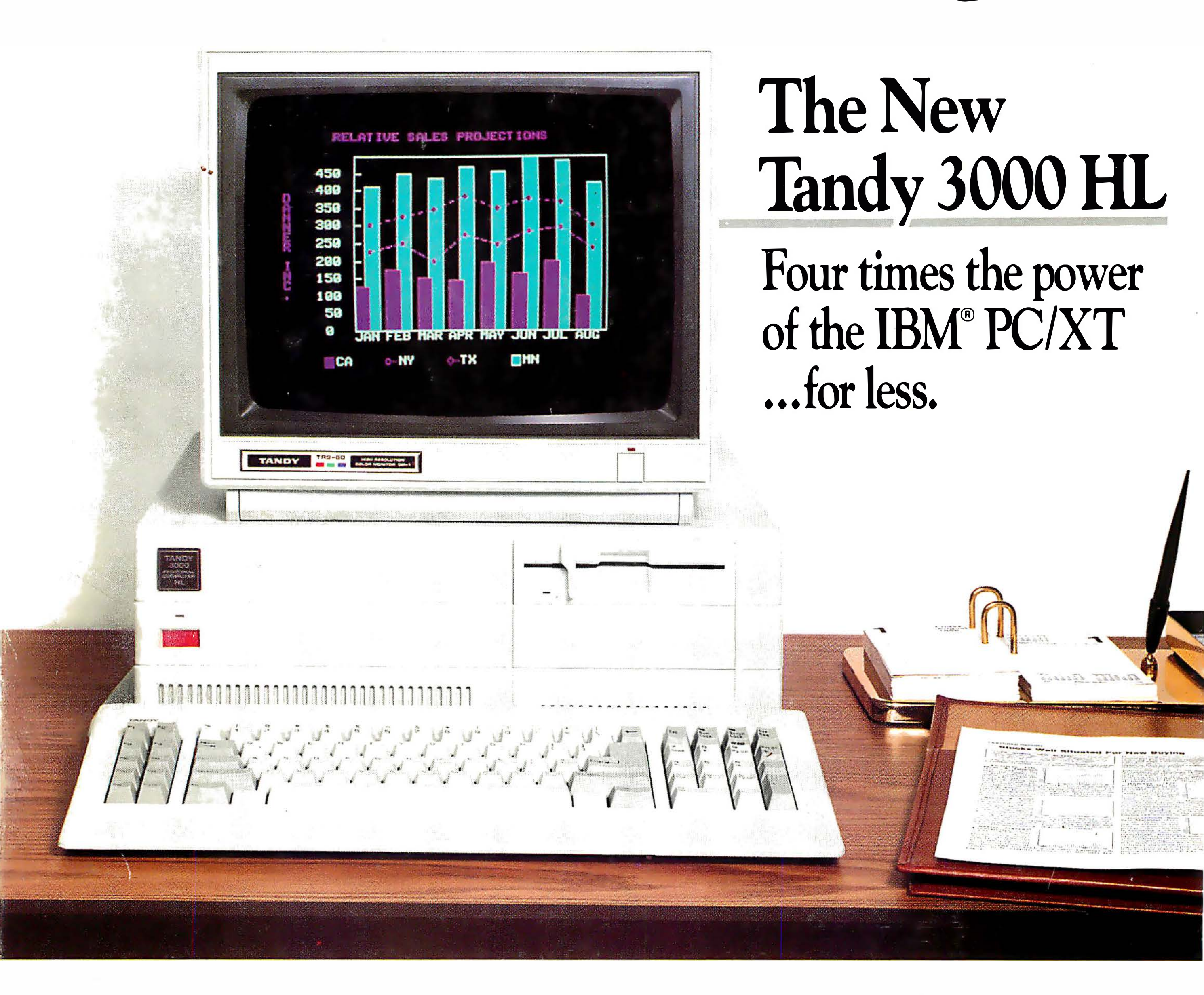
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